IS 5120 (1977): Technical requirements for rotodynamic special purpose pumps [MED 20: Pumps]

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UDC 621.67

Sixth Reprint FEBRUARY 2005
(Incorporating Amendment No. 1 and Including Amendment No. 2, 3, 4 and 5)

IS 5120 : 1977
(Reaffirmed 2001)

Indian Standard

TECHNICAL REQUIREMENTS FOR ROTODYNAMIC SPECIAL PURPOSE PUMPS
(First Revision)

REAFFIRMED 2007

1. Scope — Covers the technical requirements for rotodynamic pumps (such as centrifugal, axial flow, mixed flow, turbopumps, etc), for handling various types of liquids other than clear, cold, fresh water.

2. Standard Units

2.1 *Volume* — The standard units for volume shall be:

a) litre, and
b) cubic metre

2.2 *Rate of Flow* — The standard units for expressing rate of flow shall be:

a) litres per minute,
b) litres per second, and
c) cubic metres per hour.

2.3 *Head* — The standard unit for expressing head shall be the metre. Thus:
head in metres of liquid column

$$= \text{pressure in kgf/cm}^2 \; \frac{10}{\text{density in kg/dm}^3}$$

2.4 *Dynamic Viscosity* — The standard unit for expressing dynamic viscosity shall be the centipoise (cP).

2.5 *Kinematic Viscosity* — The standard unit for expressing kinematic viscosity shall be the centistoke (cSt).

Note — For interconversion of various units to one another, *see* Appendix A.

3. Terminology

3.1 For the purpose of this standard, the following symbols and definitions shall apply (*see* Fig. 1).

h_v = Velocity head in metres.

V = Average velocity in pipe at the cross section of measurement in m/s.

V_s = Average velocity in the suction pipe at the cross section of measurement in m/s.

g = Acceleration due to gravity in m/s².

h_s = Difference in elevation between the pump datum and the liquid level in the suction vessel when the pump is running, stated in metres

If the liquid level in the suction vessel is above the pump datum, h_s is to be taken as positive, and if the liquid in the suction vessel is below the datum, h_s is to be taken as negative.

P_s = Pressure head in closed suction vessel in metres.

h_{ss} = Static suction head in metres (+).
= Static suction lift in metres (—).

h_{fs} = Friction and entrance losses in suction pipe line in metres.

h_{gs} = Reading of a gauge on the suction side in metres.

If the value of h_{gs} is above atmospheric pressure head, plus (+) sign applies.
If the value of h_{gs} is below atmospheric pressure head, minus (—) sign applies.

z_s = Vertical distance between the liquid level in the gauge on suction side and the pump datum in metres.

If the liquid level in the gauge is above the pump datum, plus (+) sign applies.
If the liquid level in the gauge is below the pump datum, minus (—) sign applies.

Adopted 28 January 1977 | © February 1981, BIS | Gr 14

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Pumps Sectional Committee, EDC 35; Special Purpose Pumps Subcommittee, EDC 35 : 5 [Ref: Doc: EDC 35(2809)]

h_s = Total suction head in metres (+)

= Total suction lift in metres (−).

V_d = Average velocity in delivery pipe at the cross section of measurement in m/s

h_d = Difference in elevation between the pump datum and the highest point of delivery in metres.

P_d = Pressure head in closed discharge vessel in metres

h_{sd} = Static delivery head in metres

h_{fd} = Friction and exit losses in the delivery pipe line in metres

h_{gd} = Reading of a pressure gauge on delivery side in metres

Z_d = Vertical distance between the liquid level in pressure gauge on delivery side and the pump datum in metres

If the liquid level in the gauge is above the pump datum, plus (+) sign applies

If the liquid level in the gauge is below the pump datum, minus (−) sign applies.

h_d = Total delivery head in metres

H = Total head in metres.

$NPSH$ = Net positive suction head in metres

$NPSH_a$ = Available net positive suction head in metres

h_a = Atmospheric pressure head in metres, absolute

h_{sa} = Total suction head in metres, absolute

h_{vps} = Vapour pressure head of pumped liquid at pumping temperature at the suction nozzle in metres, absolute

$NPSH_r$ = Required net positive suction head in metres

The pump datum is defined as follows:

a) For horizontal units, it shall be the pump horizontal centre line (*see* Fig 2)

b) For vertical single suction pumps, it shall be the entrance eye of the first stage impeller (*see* Fig. 2).

c) For vertical double suction pumps, it shall be the impeller discharge horizontal centre line (*see* Fig 2)

3.2 *Velocity Head* (h_v) — This is the kinetic energy per unit weight of liquid handled at a given section and is expressed by the formula:

$$h_v = V^2/2g$$

3.3 *Static Suction Head* (h_{ss}) — When the liquid level in an open vessel is above the pump datum, static suction head is the difference in elevation between the pump datum and the liquid level in the suction vessel

When the pump draws liquid from a closed suction vessel, the pressure acting on the liquid level in the vessel, if above the atmospheric pressure, is to be added to h_s and if it is below the atmospheric pressure, it is to be deducted from h_s in order to arrive at the static suction head Thus,

$$h_{ss} = \pm h_s \pm P_s$$

3.4 *Total Suction Head* (h) — Suction head exists when the total suction head is above atmospheric pressure head. This is equal to the static suction head minus the friction and entrance losses in suction pipe line Total suction head as determined on test bed is the reading of a suction gauge at the suction nozzle of the pump corrected to pump datum plus velocity head at the point of measurement. Thus

$$h_s = \pm h_{ss} - h_{fs}$$

$$= \pm h_{gs} \pm Z_s + \frac{V_s^2}{2g}$$

If the value of h_s is negative, that is, the total suction head is below atmospheric pressure head, then total suction lift exists

3.5 *Static Delivery Head* (h_{sd}) — When the pump discharges into an open vessel, the static delivery head is the difference in elevation between the pump datum and the highest point of delivery

When the pump discharges into a closed vessel, the pressure acting on the liquid level in the vessel, if above the atmospheric pressure, is to be added to h_d and if it is below the atmospheric pressure, it is to be deducted from h_d in order to arrive at the static delivery head Thus,

$$h_{sd} = h_d \pm P_d$$

AMENDMENT NO. 2 DECEMBER 1983

TO

IS : 5120 - 1977 TECHNICAL REQUIREMENTS FOR ROTODYNAMIC SPECIAL PURPOSE PUMPS

(First Revision)

Corrigendum

(*Page* 41, *clause* **13.10.4**, *formula*) — Substitute '$\frac{1-\eta_1}{1-\eta_s} = \left(\frac{N_s}{N_1}\right)^n$' *for* '$\frac{1-\eta_1}{1-\eta_s} \quad \left(\frac{N_s}{N_1}\right)^n$'

(EDC 35)

Printed at Simco Printing Press, Delhi, India

AMENDMENT NO. 3 SEPTEMBER 1984

TO

IS:5120-1977 TECHNICAL REQUIREMENTS FOR ROTODYNAMIC SPECIAL PURPOSE PUMPS

(First Revision)

Alteration

[*Page 44, clause 17.6,* (*see also* Amendment No. 1)] - Substitute the following for the existing:

'17.6 *Casing* - Casing shall be of robust construction and tested to withstand a hydrostatic test pressure of 1.5 times the maximum discharge pressure experienced by the pump casing or diffuser bowl. All other components under pressure namely, column pipe, discharge elbow shall also be tested at same pressure.

NOTE 1 - The maximum pressure experienced by casing or diffuser bowl is the sum total of maximum inlet pressure and maximum differential pressure generated by pump. The maximum pressure of a pump with maximum inlet suction pressure of 0.5 kg/cm^2 and developing maximum head of 4.0 kg/cm^2, the maximum pressure experienced by casing will be 4.0 + 0.5 = 4.5 kg/cm^2. Hence the hydrostatic test pressure should be equal to 1.5 x 4.5 = 6.75 kg/cm^2.

NOTE 2 - In case of suction lift, the test shall be conducted based on maximum total head developed by pump.'

(EDC 35)

Printed at Simco Printing Press, Delhi, India

AMENDMENT NO. 4 AUGUST 1992
TO
IS 5120 : 1977 TECHNICAL REQUIREMENTS FOR ROTODYNAMIC SPECIAL PURPOSE PUMPS

(First Revision)

(*Page* 22, *clause* **5.1**, *Selection No.* 1 *and* 3) — Substitute the following for the existing entries:

"*Selection No.*	*Material of Construction*	*Relevant Specification*
1.	Bronze fitted	Grade LTB 6 of IS 318 : 1981 'Specification for leaded tin bronze ingots and castings (*second revision*)'
3.	All bronze	Grade LTB 6 of IS 318 : 1981"

(HMD 20)

Printed at Simco Printing Press, Delhi

AMENDMENT NO. 5 OCTOBER 2000
TO
IS 5120 : 1977 TECHNICAL REQUIREMENTS FOR ROTODYNAMIC SPECIAL PURPOSE PUMPS

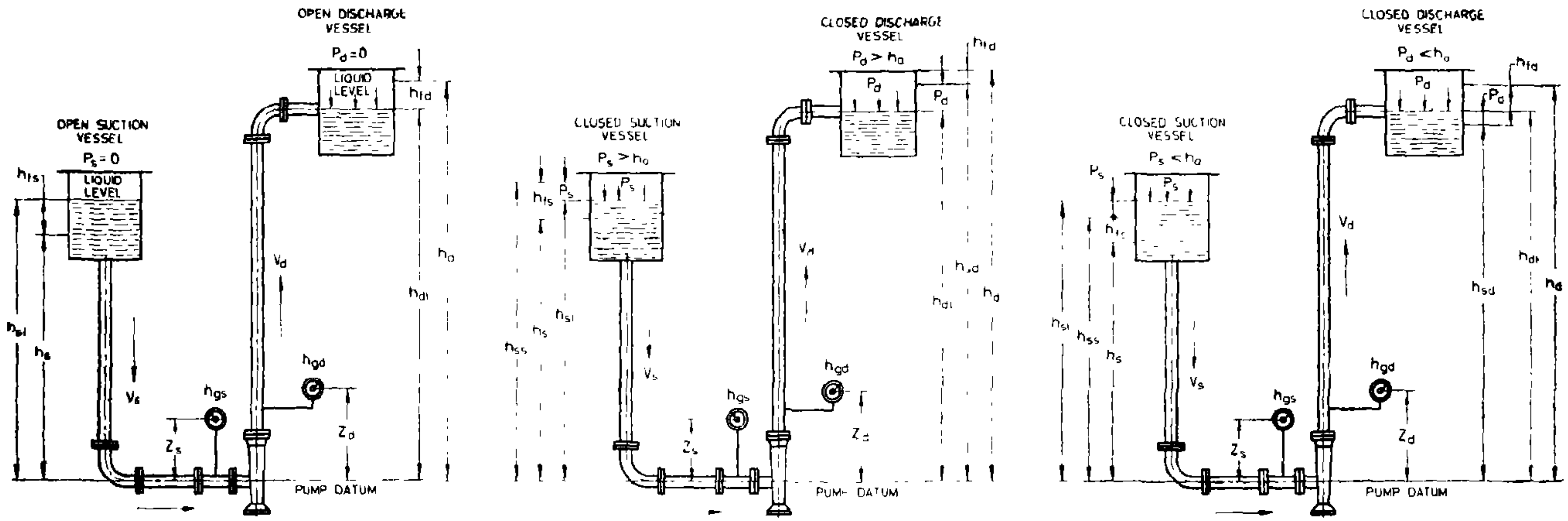
(First Revision)

(*Page* 35, *clause* **13.1**) — Substitute the following for the existing:

"**13.1** *Sampling* — The method of sampling and criteria for conformity for acceptance of lot offered for inspection shall be in accordance with IS 10572 : 1983 'Method of sampling pumps'."

(ME 20)

Printed at Simco Printing Press, Delhi



$h_{ss} = h_{sl}$

$h_s = h_{ss} - h_{fs}$

$= h_{gs} + Z_s + \frac{V_s^2}{2g}$

$h_{sd} = h_{dl}$

$h_d = h_{sd} + h_{fd}$

$= h_{gd} + Z_d + \frac{V_d^2}{2g}$

OPEN SUCTION VESSEL WITH OPEN DISCHARGE VESSEL

$h_{ss} = h_{sl} + P_s$

$h_s = h_{ss} - h_{fs}$

$= h_{gs} + Z_s + \frac{V_s^2}{2g}$

$h_{sd} = h_{dl} + P_d$

$h_d = h_{sd} + h_{fd}$

$= h_{gd} + Z_d + \frac{V_d^2}{2g}$

CLOSED SUCTION VESSEL WITH CLOSED DISCHARGE VESSEL HAVING $P_s > h_a$

$h_{ss} = h_{sl} - P_s$

$h_s = h_{ss} - h_{fs}$

$= h_{gs} + Z_s + \frac{V_s^2}{2g}$

$h_{sd} = h_{dl} - P_d$

$h_d = h_{sd} + h_{fd}$

$= h_{gd} + Z_d + \frac{V_d^2}{2g}$

CLOSED SUCTION VESSEL WITH CLOSED DISCHARGE VESSEL HAVING $P_s < h_a$

FIG. 1 TERMINOLOGY IN HEAD MEASUREMENTS FOR PUMPS

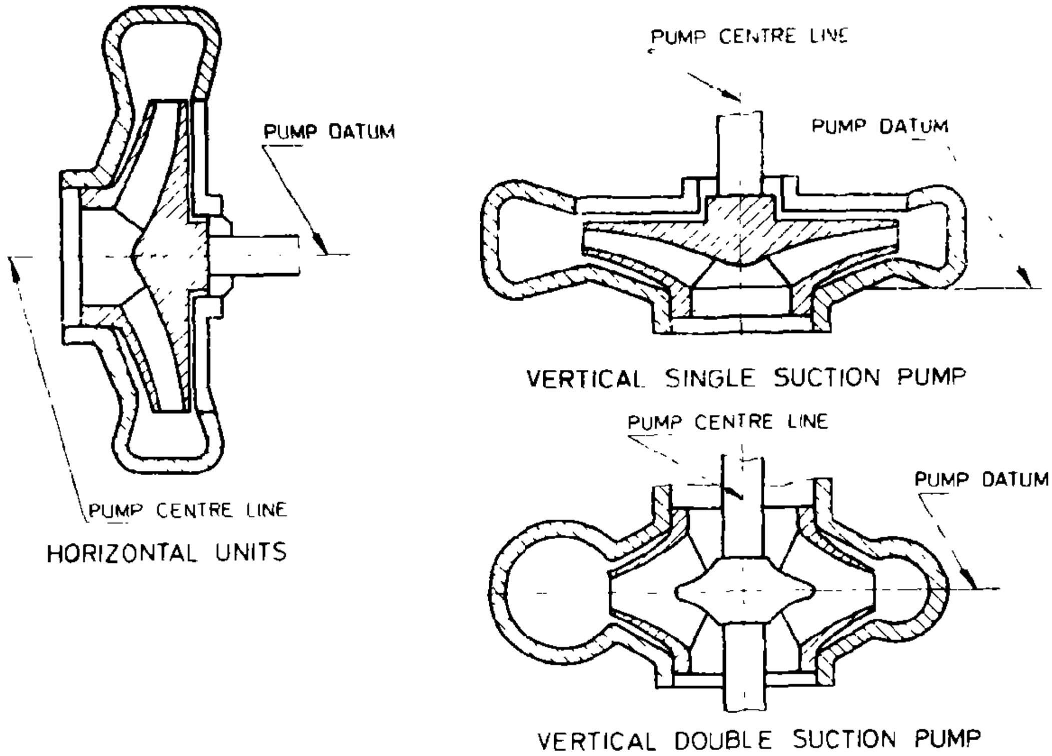


FIG. 2 PUMP DATUM

3.6 *Total Delivery Head* (h_d) — This is the sum total of the static delivery head and the friction and exist losses in the delivery pipe line.

The total delivery head, as measured on the test bed is the reading of the pressure gauge at the discharge of the pump corrected to pump datum plus the velocity head at the point of measurement Thus,

$$h_d = h_{sd} + h_{fd}$$
$$= h_{gd} + Z_d + \frac{V^2_d}{2g}$$

3.7 *Total Head* (H) — This is the measure of the energy increase per unit mass of liquid imparted to it by the pump and is, therefore, the algebraic difference of the total delivery head and the total suction head Thus,

$$H = h_d - h_s$$
$$= (h_{sd} + h_{fd}) - (\pm h_{ss} - h_{fs})$$
$$= \left(h_{gd} + Z_d + \frac{V^2_d}{2g}\right) - \left(\pm h_{gs} + Z_s + \frac{V^2_s}{2g}\right)$$

3.8 *Net Positive Suction Head* ($NPSH$) — This is the total suction head of liquid in metres, absolute, determined at the pump suction nozzle and corrected to pump datum less the vapour pressure head of the liquid at pumping temperature, at the suction nozzle in metres absolute.

Available *NPSH*, ($NPSH_a$) is a characteristic of the system in which the pump works. Thus,

$$NPSH_a = h_{sa} - h_{vpa}$$
$$= (h_a \pm h_s) - h_{vpa}$$

The required *NPSH*, ($NPSH_r$) is a function of the pump design Thus,

$$NPSH_r = h_{sa} - h_{vpa}$$
$$= \left(h_a \pm h_{gs} \pm Z_s + \frac{V^2_s}{2g}\right) - h_{vpa}$$

$NPSH_a$ shall be at least equal to or greater than $NPSH_r$.

3.9 *Specific Speed*

3.9.1 Specific speed is a term used for classifying pumps on the basis of their performance and dimensional proportions regardless of their actual size or the speed at which they operate. It is the speed expressed in revolutions per minute of an imaginary pump geometrically similar in every respect to the actual pump consideration and capable of raising 75 kg of water per second to a height of one metre.

3.9.2 Mathematically, specific speed is given by :

$$n_q = \frac{3{\cdot}65\, n\sqrt{Q}}{H^{\frac{3}{4}}}$$

where

n_q = the specific speed in revolutions per minute,

n = the speed in revolutions per minute,

Q = the discharge in cubic metres per second of a single suction impeller, and

H = the total head per stage in metres.

If the discharge is expressed in litres per minute, the expression for specific speed is written as:

$$n_q = \frac{0{\cdot}0149\, n\sqrt{Q}}{H^{\frac{3}{4}}}$$

3.10 *Driver Input* (*IP*) — The power input to the prime mover expressed in kilowatts.

3.11 *Pump Input* (*BP*) — The power applied at pump shaft expressed in kilowatts.

3.12 *Pump Output* (*LP*) — The liquid power delivered by the pump expressed in kilowatts.

3.13 *Pump Efficiency* (ηp) — The ratio of the pump output to the pump input. Thus,

$$\eta_p \text{ percent} = \frac{LP}{BP} \times 100$$

3.14 *Overall Efficiency* (ηo) — The ratio of the pump output to the driver input. Thus,

$$\eta_o \text{ percent} = \frac{LP}{IP} \times 100$$

4. Nomenclature

4.0 The names of the parts commonly used with rotodynamic pumps for special purposes are given in Tables 1 to 6.

4.1 *Horizontal Centrifugal Pumps* — Table 1 lists the names of parts commonly used in connection with horizontal centrifugal pumps for special purposes (*see* Fig. 3 to 6).

TABLE 1 NOMENCLATURE OF PARTS COMMONLY USED IN HORIZONTAL CENTRIFUGAL PUMPS

(*Clauses* 4.0 *and* 4.1, *and* Fig. 3 to 6)

Part No.	Name of Part	Brief Description and Function of Parts
1.	Air vent	A valve for removing air during priming operation.
2.	Balancing disc or drum	The rotating member of a hydraulic balancing device.
3.	Balancing ring	The stationary member of a hydraulic balancing device.
4.	Bearings, ball and roller	Rolling bearings.
5.	Bearing cover	A protective cover for the bearings.
6.	Bearing, driving end	The bearing nearest to the coupling or pulley.
7.	Bearing housing	An overhung casting accommodating the bearings.
8.	Bearing, non-driving end	The bearing farthest from the coupling or pulley.
9.	Bearing pedestal	A casting, with supporting feet, accommodating the bearing or bearings.
10.	Casing	In the case of horizontally split casing pumps, the casing includes both the lower and the upper halves. In the case of multistage pumps, the casing includes suction casing, delivery casing and the casing for the intermediate stages of the pump. In the case of end suction pump, the portion of the pump which houses the impeller and includes the volute.
11.	Casing, delivery	In the case of multistage pumps, the casing which is connected to the delivery piping.
12.	Casing, lower half	The lower or supporting half of the casing of a horizontally split casing pump.
13.	Casing, suction	In the case of multistage pumps, the casing which is connected to the suction piping.
14.	Casing, upper half	The upper or removable half of the casing of a horizontally split casing pump.
15.	Casing ring	A stationary replaceable ring to protect the casing at a running fit with the impeller ring or the impeller.
16.	Companion flanges	Flanges used to connect the pump to the piping.
17.	Coupling bolts	Bolts provided with rubber bushes or any other flexible material for transmitting power from the driver to the pump. **Note** — In many designs power is transmitted in other ways.
18.	Coupling, flexible	A device flexibly connecting the pump shaft and the motor shaft for power transmission.
19.	Coupling, primemover half	The half of the flexible coupling which is fitted on the primemover shaft.
20.	Coupling, pump half	The half of the flexible coupling which is fitted on the pump shaft.
21.	Deflector, liquid	A device to protect bearings by slinging off stuffing box leakage.

(*Continued on page* 8)

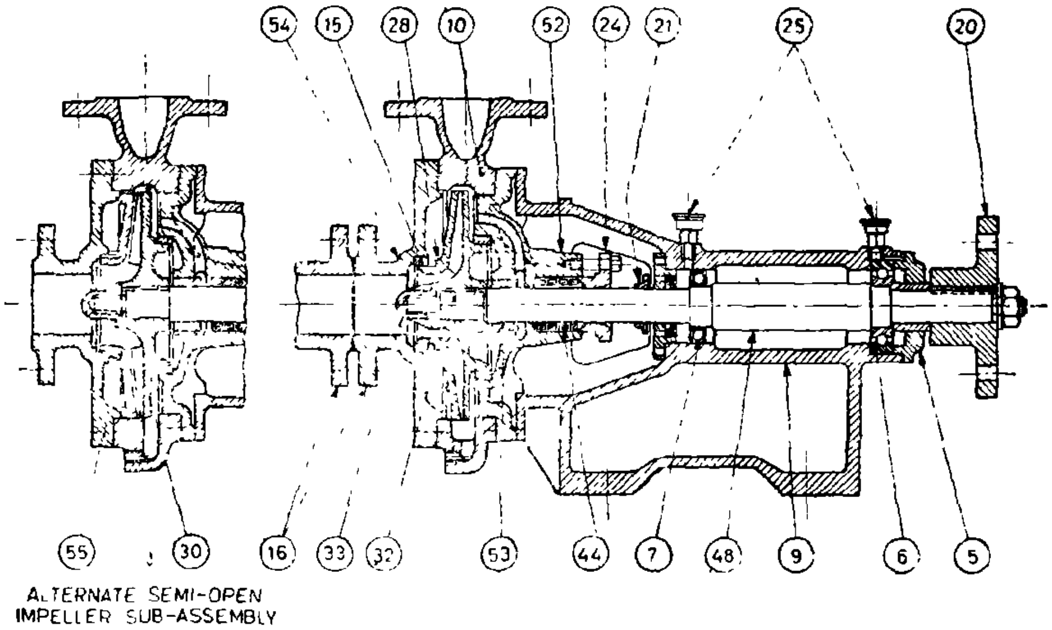


FIG. 3 TYPICAL ILLUSTRATION OF END SUCTION PUMP PARTS

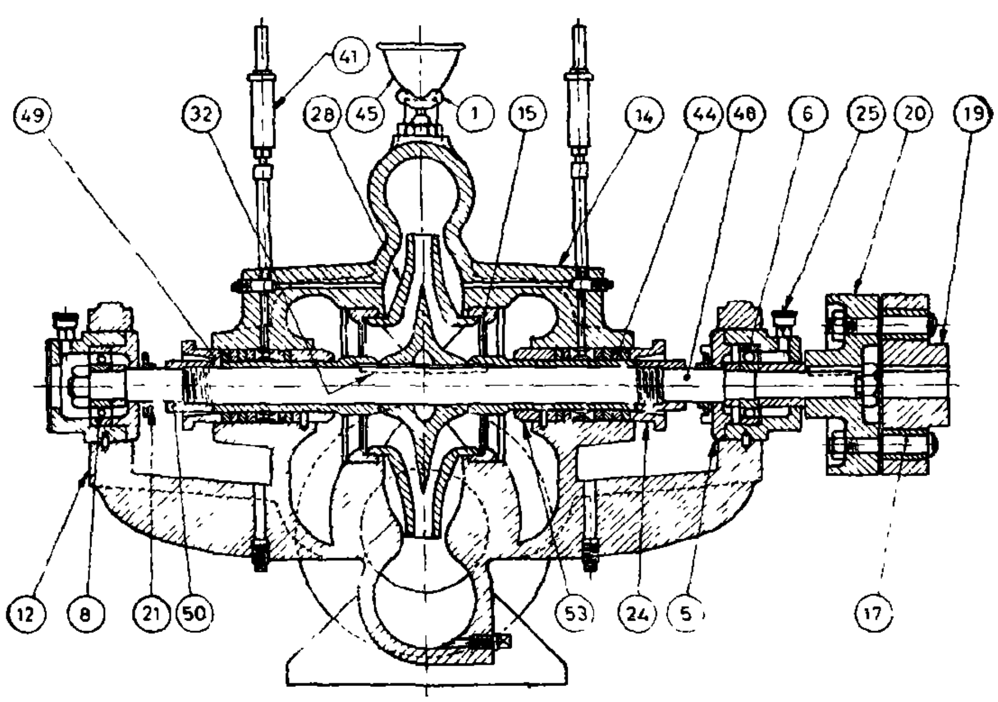


FIG. 4 TYPICAL ILLUSTRATION OF DOUBLE SUCTION PUMP PARTS

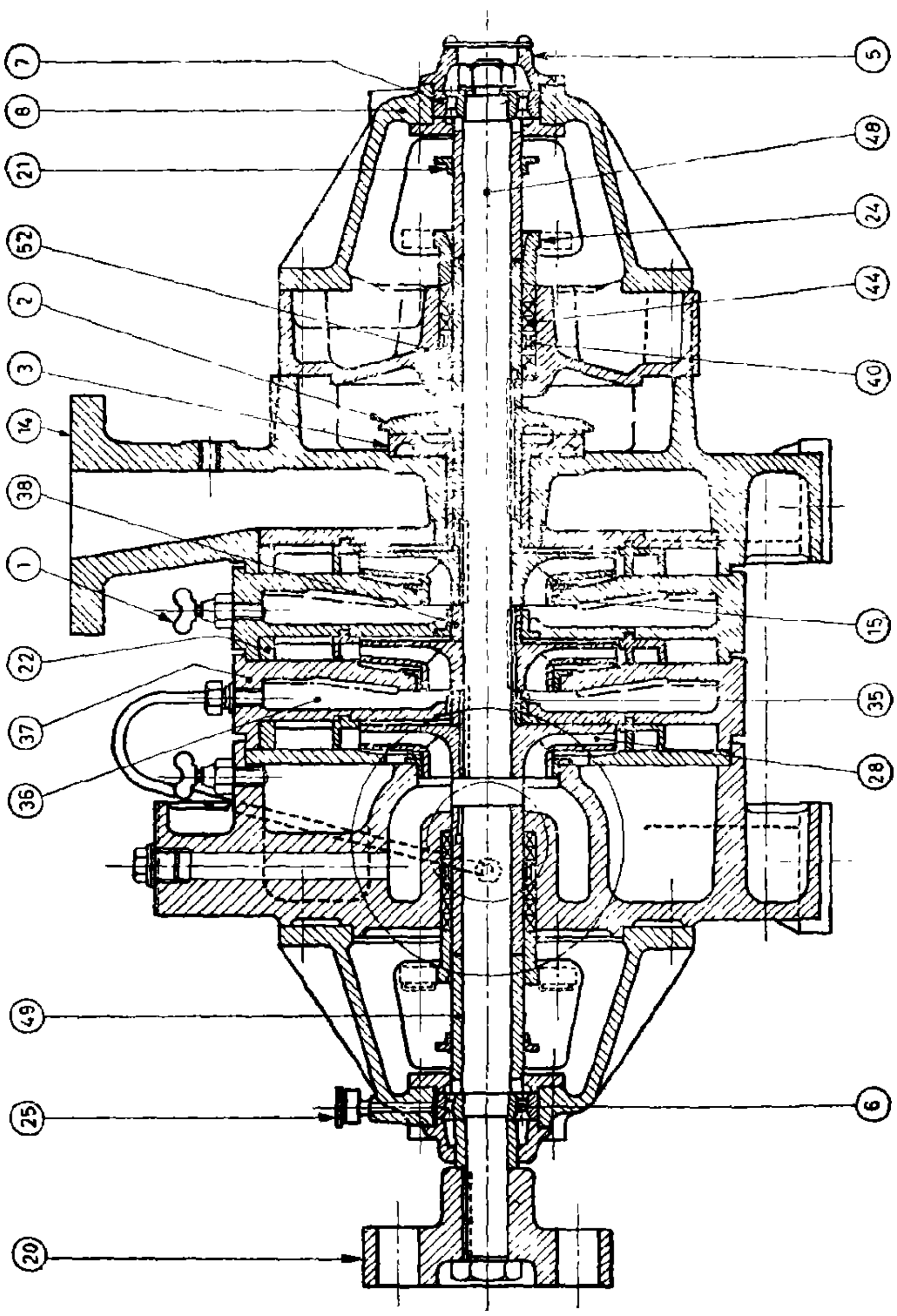


FIG. 5 TYPICAL ILLUSTRATION OF MULTISTAGE PUMP PARTS

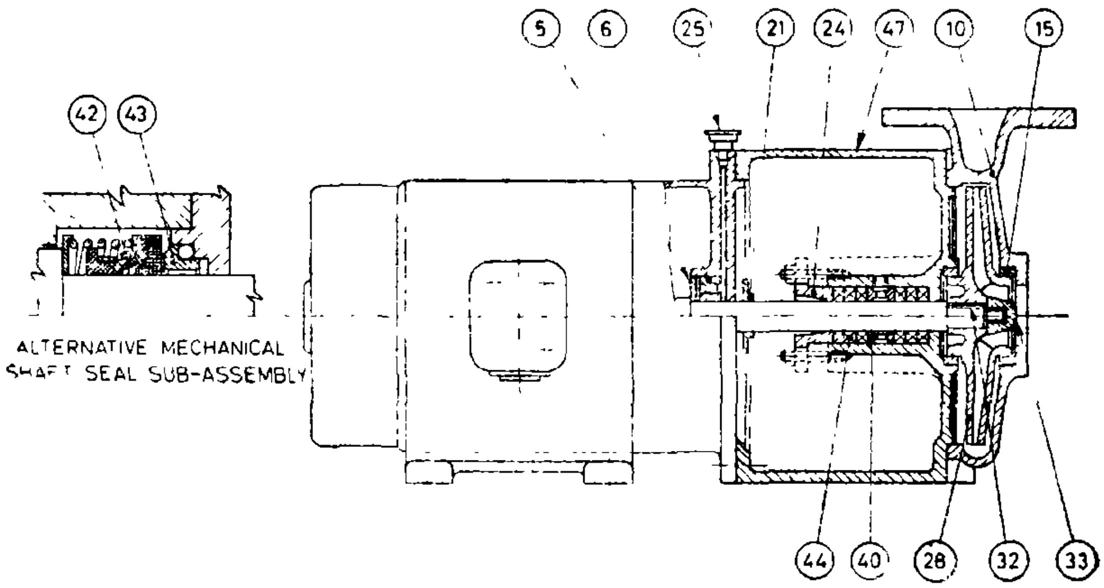


FIG 6 MONOSET PUMP PARTS

TABLE 1 NOMENCLATURE OF PARTS COMMONLY USED IN HORIZONTAL CENTRIFUGAL PUMPS — *Contd*

Part No.	Name of Part	Brief Description and Function of Parts
22.	Diffuser	A component adjacent to the impeller discharge which has multiple passages of increasing area for converting velocity head in to pressure head.
23.	Gasket	A jointing to provide leakage-proof joint.
24.	Gland	A follower which compresses packing in a stuffing box.
25.	Grease cup	A receptacle for containing and supplying grease.
26.	Grease nipple	A non-return valve through which grease is pumped to the bearings.
27.	Impeller	A rotating element producing head.
28.	Impeller, enclosed	An impeller having shrouds (walls) on both sides.
29.	Impeller, open	An impeller without any shroud.
30.	Impeller, semi-open	An impeller with a single shroud.
31.	Impeller hub sleeve	A replaceable, cylindrical wearing part mounted on the extended pump impeller hub.
32.	Impeller key	A parallel sided piece used to prevent the impeller from rotating relative to the shaft.
33.	Impeller nut	A threaded piece used to secure the impeller on the shaft usually provided complete with locking device.
34	Impeller ring	A replaceable ring fitted on the impeller shroud hub where it rotates in the casing or casing ring (*see* Fig. 19).
35	Interstage bushing	A replaceable bushing fitted into the stage piece through which the shaft or shaft sleeve rotates
36.	Interstage crossover	A specially designed piece that carries the flow from one stage to another in a multi-stage pump.
37.	Interstage diaphragm	A removable stationary partition between stages of a multistage pump.
38.	Interstage sleeve	A cylindrical piece mounted on the pump shaft between impellers of a multistage pump.
39.	Jack shaft	An auxiliary shaft through which the pump shaft is driven.
40.	Lantern ring	Sealing liquid is supplied through the lantern ring into the stuffing box to prevent air-leakage into the pump.
41.	Lubricator	A device for applying lubricant to the point of use.
42.	Mechanical seal (shaft seal), rotating element	A flexible device mounted on the shaft in the stuffing box and having lapped sealing face held against the stationary sealing face.
43.	Mechanical seal (shaft seal), stationary element	A sub-assembly consisting of one or more parts mounted on the stuffing box and having a lapped sealing face.
44.	Packing, stuffing box	A pliable lubricated material used to provide a seal around the portion of the shaft located in the stuffing box.
45.	Priming funnel	A funnel used for priming the pump.
46.	Priming funnel cock	A valve to control priming liquid supply.
47.	Pump bracket	A casting in monosets, accommodating pump on one side and motor on the other.
48.	Pump shaft	A shaft which holds the rotating impeller and transmits the power.
49.	Shaft sleeve	A replaceable sleeve for protecting the shaft where it passes through the stuffing box and stage bushings
50.	Shaft sleeve nut	A threaded piece used to locate the shaft sleeve on the shaft.
51.	Sleeve bearing	A bush type bearing.
52.	Stuffing box	A portion of the casing or cover through which the shaft extends and in which the packing and gland or a mechanical seal is placed to prevent leakage.
53.	Stuffing box bushing	A replaceable bushing fitted into the stuffing box throat through which the shaft or shaft sleeve rotates
54.	Suction cover	A removable piece (with which the inlet nozzle may be integral) used to enclose the suction side of the casing of an end suction pump.
55.	Wear plate	A replaceable plate against which the semi-open or open impeller rotates.

4.2 *Vertical Turbine Pumps*

4.2.1 The names of parts commonly used in connection with the vertical turbine pumps for special purposes, driven by hollow shaft motors are listed in Table 2 (*see* Fig. 7 to 9).

TABLE 2 NOMENCLATURE OF PARTS COMMONLY USED IN VERTICAL TURBINE PUMPS

(*Clauses* 4.0, 4.2.1 *and* Fig 7 to 9)

Part No.	Name of Part	Brief Description and Function of Parts
1.	Air line	A thin tube installed alongside the pump and submerged in liquid for the purpose of finding the liquid level.
2.	Automatic lubricator	It is a solenoid-operated lubricator providing oil to the line shaft bearings automatically.
3.	Bearing holder	Holds rubber or plastic bearing for open line shaft of water-lubricated pump
4.	Bearing retainer	Retains open line shaft bearing in the bearing holder.
5.	Bottom column pipe	First section of column immediately above discharge case.
6.	Bowl	It guides flow received from one impeller to the next impeller above It houses impeller and bowl bearing
7.	Bowl bearing	Bearing for the impeller shaft in each bowl.
8.	Column flange	These are mounted on two ends of each section of column pipe if flanged column construction is used. May take the form of lugs
9.	Column pipe	The rising main through which liquid goes up
10.	Column pipe adaptor	Transition piece between the bowl assembly and the column pipe used, if required
11.	Column pipe couplings	For connecting column pipe section having threaded ends.
12.	Column pipe spacer	Aligning ring between two column ends. Use of this is optional
13.	Depth gauge	Instrument for indicating liquid level. It may be direct or indirect reading type
14.	Discharge case	It is situated between top bowl and pump column and guides flow from one to the other.
15	Discharge case bearing	Bearing in discharge case which also serves to connect shaft tubes for oil-lubricated models
16.	Discharge head gland	This tightens packing at discharge head and guides head shaft.
17.	Flanged column	The column pipe section with bolting arrangement at the two ends.
18.	Foot valve cum strainer (not shown in Fig 8)	To hold liquid in liquid columns so as to lubricate the bearings of pumps.
19.	Guide spiders	To stabilize shaft enclosing tube.
20.	Head shaft	The inner shaft passing through the driver hollow shaft and connecting the line shaft
21.	Head shaft coupling	It connects head shaft with line shaft.
22.	Impeller	The rotating elements producing head. It receives liquid and impels it to bowl passage. It may be enclosed or semi-enclosed.
23.	Impeller adjusting nut	Provided on head shaft for adjusting impeller vertically
24.	Impeller collet	Split taper sleeve for locking impeller on impeller shaft.
25.	Impeller seal ring	Wearing ring providing seal to enclosed impellers It may be either on the impeller or in the bowl or on both
26.	Impeller shaft	Impellers are mounted on it It is coupled to the line shaft
27.	Impeller shaft coupling	It connects line shaft to impeller shaft.
28.	Line shaft	Sections of shaft between the impeller shaft and head shaft.
29.	Line shaft bearing	Bearing for the line shaft sections Also acts as coupler for shaft enclosing tube in oil-lubricated models
30.	Line shaft couplings	These connect line shaft sections.
31.	Liquid deflector	Device to throw off leakage liquid from discharge head gland, thus preventing entry into driver unit.
32.	Manual lubricator	Lubricator with an arrangement for manually adjusting the oil flow to line shaft bearings.
33.	Non-reverse ratchet	Device to prevent reverse rotation of pump.
34.	Open line shaft sleeve	Sleeve operating as journal for the bearings of water-lubricated pumps.
35.	Pre-lubricating tank (not shown in Fig. 8)	When supplied, it provides lubricants to the bearings of the pumps.
36.	Safety clutch	Top half is mounted on the head shaft and the bottom half on the driving shaft for the purpose of dis-engagement if unscrewing of shafts takes place during reverse rotation.
37.	Sand collar	It prevents entry of sand into the suction case bearing
38.	Shaft enclosing tube	It encloses line shafts
39.	Stuffing box	Used for sealing off liquid at discharge head along head shaft. Acts also as a guide to head shaft.
40.	Stuffing box packing	Used in the stuffing box for sealing off liquid from discharge head.

(*Continued on page* 11)

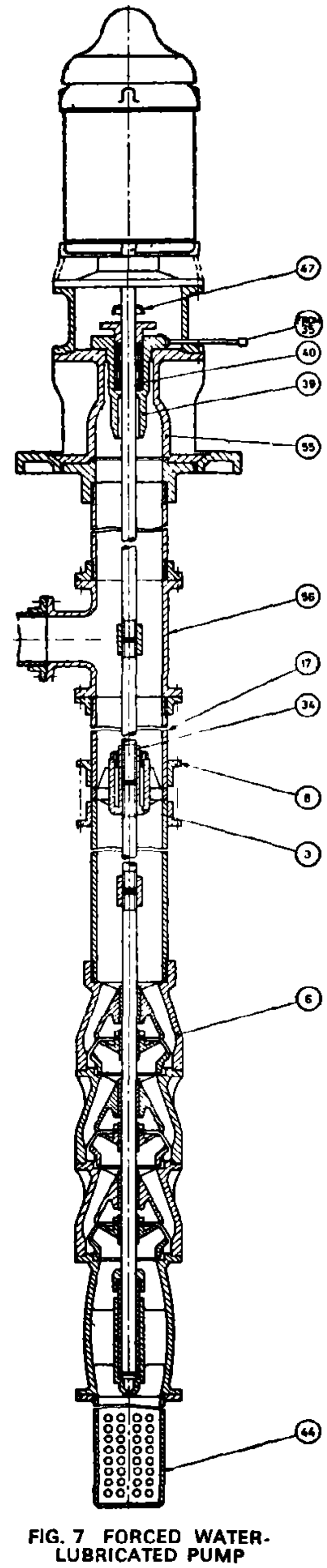


FIG. 7 FORCED WATER-LUBRICATED PUMP

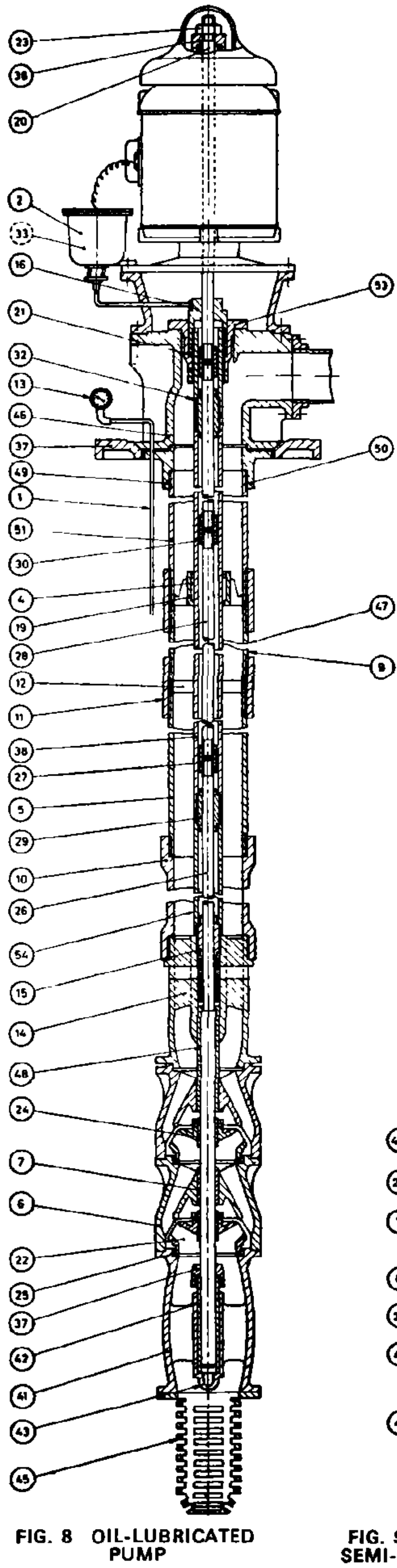


FIG. 8 OIL-LUBRICATED PUMP

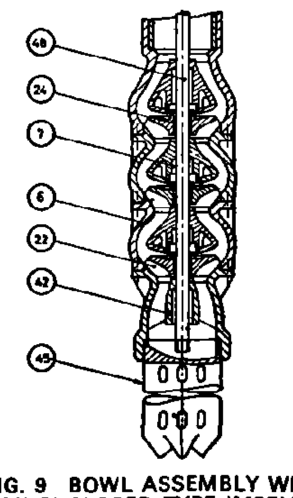


FIG. 9 BOWL ASSEMBLY WITH SEMI-ENCLOSED TYPE IMPELLER

4.2.2 The names of the parts commonly used in connection with forced water-lubricated vertical turbine pumps driven by solid shaft motors are listed in Table 3 (*see* Fig. 10 to 13).

TABLE 2 NOMENCLATURE OF PARTS COMMONLY USED IN VERTICAL TURBINE PUMPS — *Contd*

Part No.	Name of Part	Brief Description and Function of Parts
41.	Suction case	It guides the flow into the eye of the lowest impeller and carries the suction case bearing of the impeller shaft
42.	Suction case bearing	The guide bearing of the impeller shaft located in suction case.
43.	Suction case plug	It prevents entry of sand into the suction case bearing and provides a port to grease this bearing
44.	Suction pipe	It helps to streamline flow to suction case and provides a safety measure in case of drawn down level going below the lowest impeller.
45.	Suction strainer	It prevents entry of large foreign matter
46.	Surface discharge head	It supports column and driver and discharges liquid from pump column.
47.	Threaded column	Column pipe with threaded ends.
48.	Top bowl bearing	A long bearing usually inserted in the top bowl.
49.	Top column flange	A connecting piece between column pipe and discharge head.
50.	Top column flange gasket	It prevents leakage of liquid from top column flange.
51.	Top column pipe	First section of column pipe below discharge head.
52.	Tube tension nipple	A short piece of shaft tube generally provided at the top end of shaft tube assembly to provide additional bearing close to the head shaft or to make up the required length of pump assembly. It is connected to the tube tension plate.
53.	Tube tension plate	Used for tensioning shaft tubes for alignment
54.	Tubing adaptor	A short piece connecting discharge case to the shaft tube
55.	Underground discharge head	Supports driver and column assembly when discharge is below surface.
56.	Underground discharge tee	This takes off discharge below the base plate, also forms part of column.

TABLE 3 NOMENCLATURE OF PARTS COMMONLY USED IN FORCED WATER-LUBRICATED VERTICAL TURBINE PUMPS WITH SOLID SHAFT MOTOR

(*Clauses* 4.0, 4.2.2 *and* Fig. 11 to 13)

Part No.	Name of Part	Brief Description and Function of Parts
1.	Air cock	To remove air from shaft enclosing tube
2.	Bearing holder	Holds rubber or plastic bearing for open line shaft of water-lubricated pump.
3.	Bearing segment	Provided to take axial thrust of the pump.
4.	Booster impeller	It delivers high pressure water to line shaft bearing.
5.	Bottom shaft enclosing tube	It is used to carry clear water from transmission bearing to upper pump bearing.
6	Bowl	It guides flow received from one impeller to the next impeller above It houses impeller and bowl bearing
7.	Bowl bearing	Bearing for the impeller shaft in each bowl
8.	Clear water pipe	It is used as inlet of clear water to booster pump
9.	Column pipe	The rising main through which liquid goes up
10.	Cooling coil	Water is circulated through this coil to cool lubricating oil
11.	Cooling water inlet	Cooling water supplied to cooling coils provided in thrust bearing housing.
12.	Cooling water outlet	To remove cooling water from thrust bearing housing.
13.	Coupling bushes	Torque is transmitted from motor coupling to pump coupling through this.
14.	Cover	To protect sealing ring.
15.	De-aerating valve	To remove air from column pipe.
16.	Distance ring	It is used between sealing ring and bottom of top bowl bearing.
17.	Distance ring	Used as spacer between pump coupling and nuts
18.	Distance sleeve	Used as spacer between two impellers.
19.	Distance sleeve	It acts as spacer between shaft and booster impeller.
20.	Gland sepage drain	To take out water collected in stuffing box housing.
21.	Guide casing	It guides water from first booster impeller to second.
22.	Head shaft	It connects motor shaft and line shaft.
23.	Head shaft sleeve	It is provided under stuffing box packings
24.	Impeller	The rotating element producing head. It receives liquid and impels it to bow passage. It may be enclosed or semi-enclosed
25.	Impeller lock nut	To lock impeller on the shaft

(*Continued*)

TABLE 3 NOMENCLATURE OF PARTS COMMONLY USED IN FORCED WATER-LUBRICATED VERTICAL TURBINE PUMPS WITH SOLID SHAFT MOTOR — *Contd*

Part No.	Name of Part	Brief Description and Function of Parts
26	Impeller seal ring	Wearing ring providing water seal to enclosed impellers This may be fitted in bowl or on impellers.
27	Impeller shaft	Impellers are mounted on it It is coupled to the line shaft
28	Impeller shaft coupling	It connects line shaft to impeller shaft
29	Head shaft bearing	Lined with white metal and supports the head shaft
30	Key, thrust collar	It is used to fit thrust collar on shaft
31.	Key, coupling	Used to fit pump coupling on the shaft
32	Key, ratchet pin housing	It fits ratchet pin housing on pump coupling boss
33.	Line shaft	Sections of shaft between the impeller shaft and head shaft
34	Line shaft bearing	Bearing for the line shaft sections
35	Lock nut	Nut to lock conical coupling
36	Lower bearing cover	It is used as bottom cover for thrust bearing housing.
37	Lower bowl bearing	The guide bearing of the impeller shaft in the bottom bowl
38	Motor stool	It supports motor
39	Nipple	It is tightened on lock nut
40.	Nuts	Used for locating sleeve
41	Nuts	Provided on head shaft for adjusting impeller vertically
42	Oil level gauge	It is used to measure level of oil in thrust bearing housing
43.	Enclosed line shaft sleeves	Sleeve operating as journal for the bearings of forced water lubricated pumps
44	Pressure gauge	To measure pressure developed by the pump
45	Pump half coupling	It is coupled to motor coupling and drives head shaft
46	Pump stool	Supports driver and column assembly when discharge is below surface
47.	Ratchet pin	It locks against upper bearing cover during reverse rotation.
48	Ratchet pin housing	It is fixed on the pump coupling and houses ratchet pins
49	Rubber joint ring	It prevents water leakage from bottom shaft enclosing tube to top bowl
50	Rubber joint ring	Prevents leakage from a) joint of bowl (upper-most) and taper rising pipe, b) joint of shaft enclosing tube and line shaft bearing, c) joint of top shaft enclosing tube and stuffing box housing, d) top column flange, and e) pump stool and stuffing box housing
51	Rubber ring	Rotating element fixed to thrust collar It comes into contact with bearing segment when axial load acts
52	Sealing ring	Prevents water leakage from bowl to top bowl bearing
53	Shaft enclosing tube	It encloses line shafts
54	Stuffing box gland	This tightens packing at discharge head and guides head shaft
55	Stuffing box housing	Used on forced water-lubricated pumps for sealing off water at discharge head along head shaft Acts also as a guide to head shaft
56	Stuffing box packing	Used in the stuffing box for sealing off water from discharge head
57	Suction bail	It guides the flow into the eye of the lowest impeller
58	Taper rising pipe	It delivers water from top bowl to column pipe
59	Thrust bearing housing	It houses journal bearing It is fixed with pump stool
60	Thrust bearing dip	It is used as shield for lubricating oil It is made in two halves
61	Thrust collar	Fixed on shaft and supports the runner ring.
62.	Top bowl bearing	A long bearing usually inserted in the top bowl.
63	Two-piece ring	The ring is in two halves and is fitted on shaft groove, locates coupling
64	Underground discharge tee	This takes off discharge below the base plate Also forms part of column
65.	Upper bearing cover	Used as cover on thrust bearing housing, it has ratchet teeth
66	Upper shaft enclosing tube	It guides clear water to first transmission bearing
67	Upper shaft sleeve	Provided in uppermost bowl and used as spacer

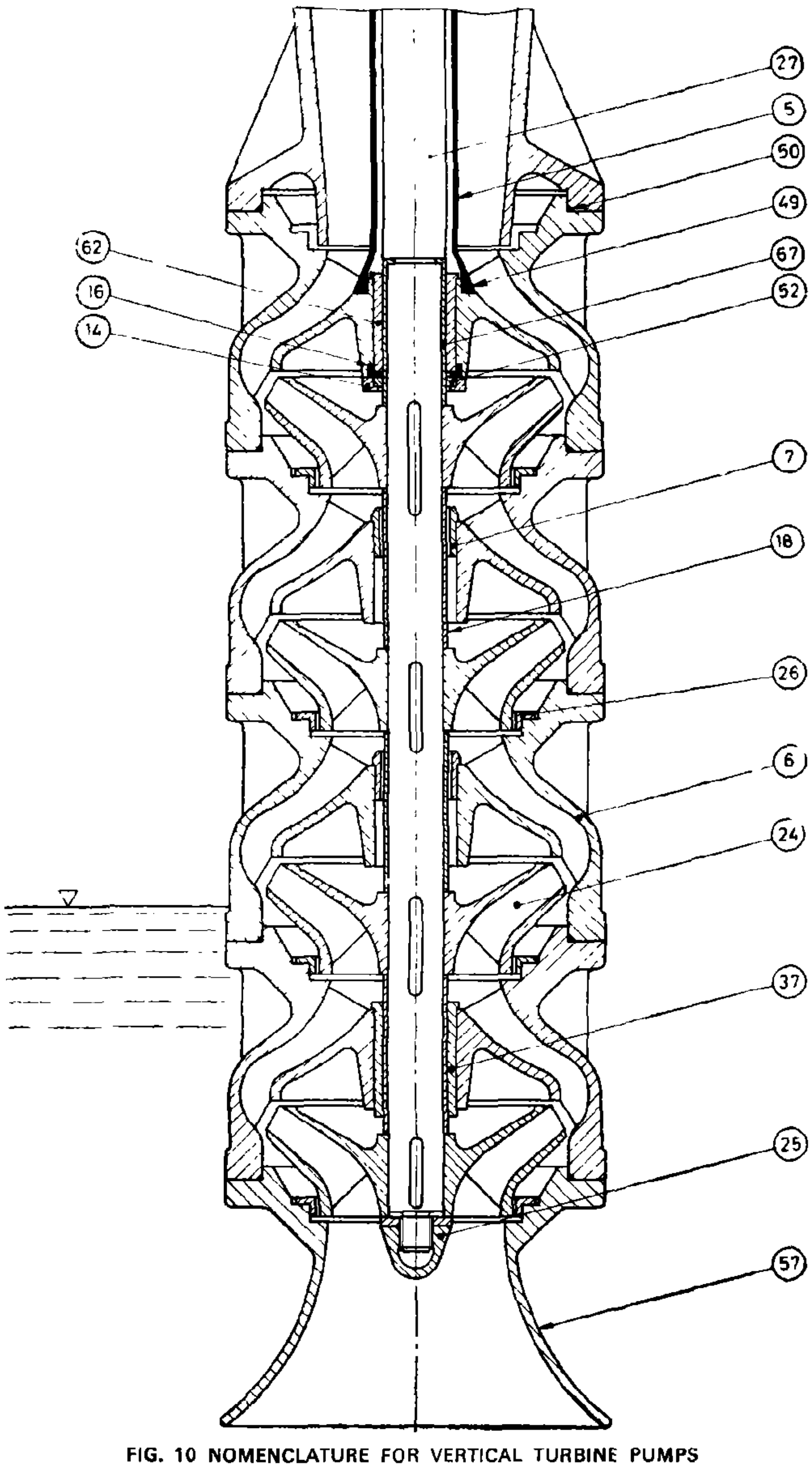


FIG. 10 NOMENCLATURE FOR VERTICAL TURBINE PUMPS (FORCED WATER-LUBRICATED AND WITH SOLID SHAFT MOTOR)

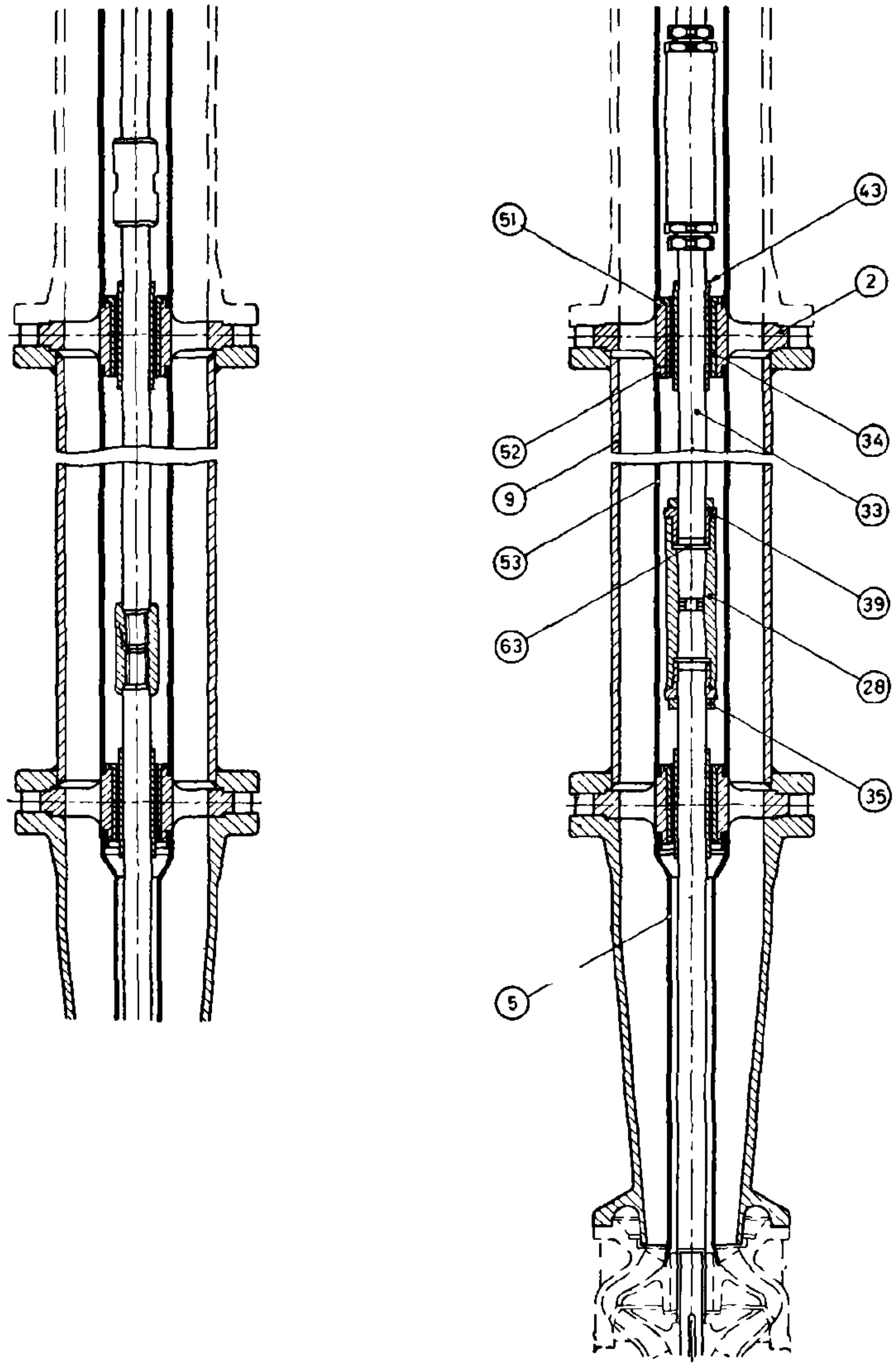


FIG. 11 NOMENCLATURE FOR VERTICAL TURBINE PUMPS
(FORCED WATER-LUBRICATED AND WITH SOLID SHAFT MOTOR)

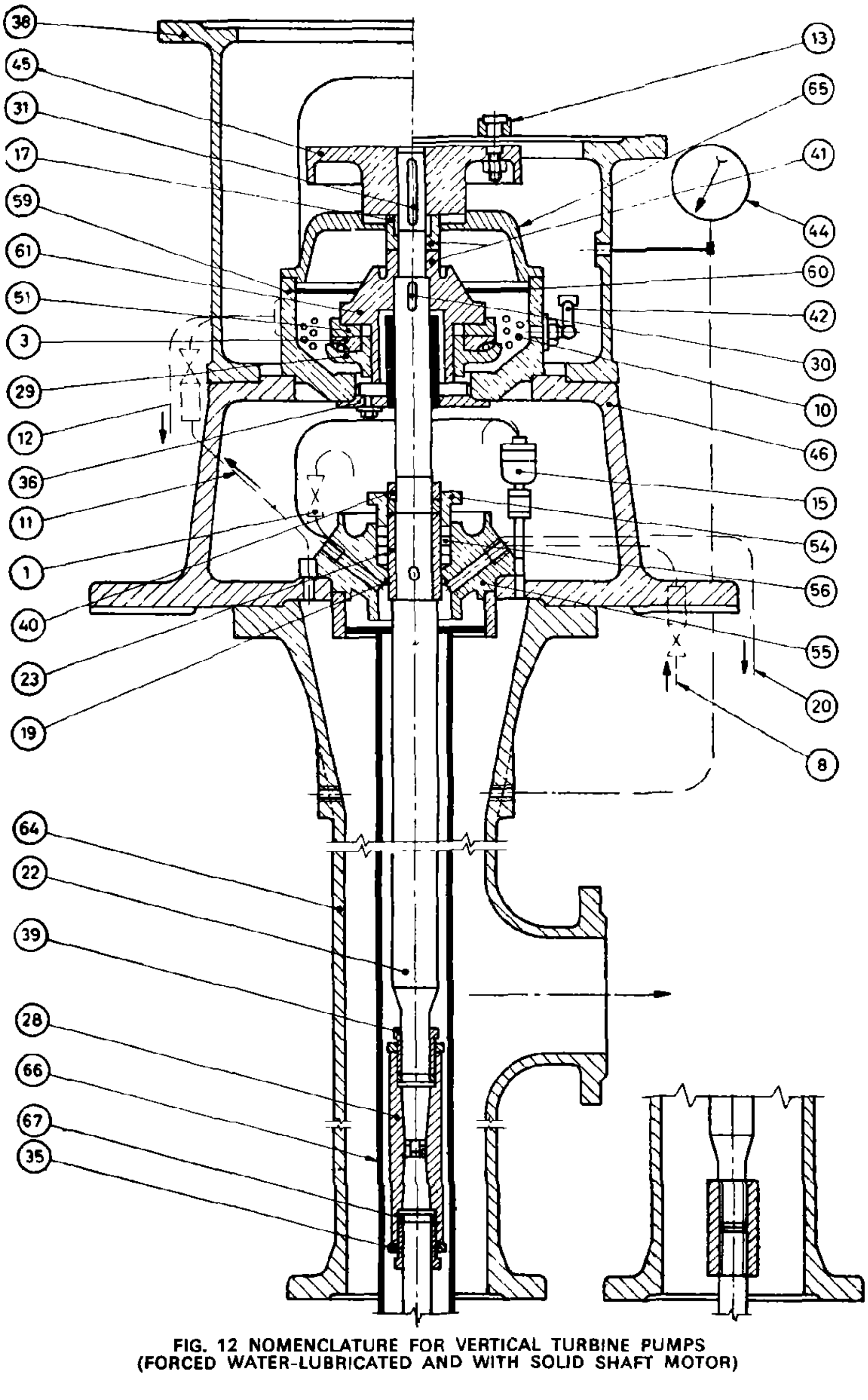
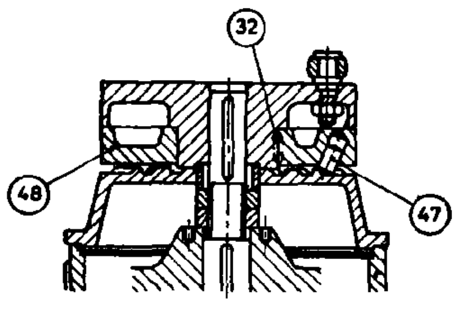
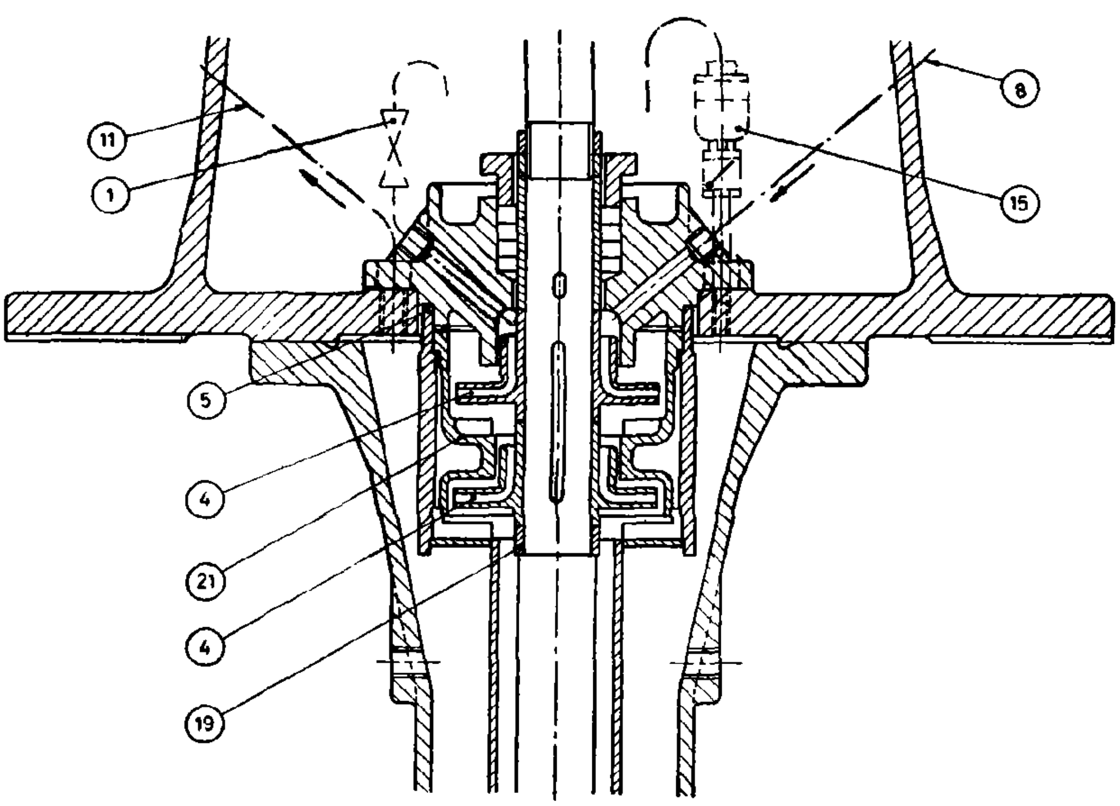


FIG. 12 NOMENCLATURE FOR VERTICAL TURBINE PUMPS (FORCED WATER-LUBRICATED AND WITH SOLID SHAFT MOTOR)



13A



13B

FIG. 13 NOMENCLATURE FOR VERTICAL TURBINE PUMPS (FORCED WATER-LUBRICATED AND WITH SOLID SHAFT MOTOR)

4.3 *Volute Pumps* — The names of the parts commonly used in connection with volute pumps for special purposes are listed in Table 4 (*see* Fig. 14).

4.4 *Dry-Pit Non-clog Vertical Centrifugal Pumps* — The names of the parts commonly used in connection with dry-pit non-clog vertical centrifugal pumps are listed in Table 5 (*see* Fig. 15).

TABLE 4 NOMENCLATURE OF PARTS COMMONLY USED IN VERTICAL VOLUTE PUMPS
(*Clauses* 4.0, 4.3 *and* Fig 14)

Part No.	Name of Part	Brief Description and Function of Parts
1.	Bearing bush	A part incorporated in the pump bracket and acts as a bearing for the pump shaft.
2.	Casing	A portion of the pump which houses the impeller and incorporates the volute.
3.	Casing ring	A stationary replaceable ring to protect the casing at a running fit with the impeller ring or the impeller.
4.	Clamps for oil pipes	The clamps to keep the oil pipe in position for lubrication to the bearings.
5.	Control needle valve	A valve to control the flow of lubricant.
6.	Guide spider	A part which contains the bearing and acts as a vibration dampener.
7.	Guide spider bearing bush	A part incorporated in the guide spider and acts as a bearing for the line shaft.
8.	Head shaft	A shaft connecting the line shaft to the motor shaft.
9.	Head shaft coupling	A threaded part which connects the line shaft with the head shaft
10.	Impeller	A rotating element producing head.
11.	Line shaft	A part connecting the head shaft to the pump shaft and transmits the power from head shaft to the pump shaft.
12.	Line shaft coupling	A part which connects the two line shafts.
13.	Motor stool bearing bush	A part incorporated in the motor stool and acts as a bearing for the last line shaft.
14.	Oil lubricator	A container with sufficient number of openings to feed the oil for lubrication to the bearings.
15.	Operating needle valve	A valve which operates the lubricator.
16.	Pump shaft coupling	A part which connects the pump shaft and line shaft rigidly.
17.	Pump shaft	A shaft which holds the rotating impeller and transmits the power
18.	Seal	A part which does not allow the liquid to go upward and damage the other parts.
19.	Shaft sleeve	A replaceable sleeve for protecting the pump shaft.
20.	Skirt	A part functioning as a base for the motor
21.	Suction cover	A removable piece (with which the inlet nozzle may be integral) used to enclose the suction side of the casing.
22.	Suspension pipe	A part which encloses the line shafts and supports the motor stool.
23.	Thrust bearing	A bearing located in the motor stool to take care of the thrust load due to hydraulic axial thrust and weight of the rotating parts in case of solid shaft motor and located in motor top in case of hollow shaft motor

TABLE 5 NOMENCLATURE OF PARTS COMMONLY USED IN DRY-PIT NON-CLOG VERTICAL CENTRIFUGAL PUMPS
(*Clauses* 4 0 *and* 4.4, *and* Fig. 15)

Part No.	Name of Part	Brief Description and Function of Parts
1.	Bearing cover	A protective cover for the bearings
2.	Coupling motor shaft half	A flange which connects the motor shaft to the flexible shaft.
3.	Coupling pump shaft half	A flange which connects the pump shaft to the flexible shaft.
4.	Deflector	A device to protect bearings by slinging off stuffing box leakage.
5.	Line shafts	Shafts which transmit power from motor shaft to pump shaft.
6.	Gearing housing	A cover for the pump shaft; it also houses the bearings for the pump shaft
7.	Adapter	An extension to the frame connecting it to the pump casing; it encloses stuffing box.
8.	Grease nipple	A non-return valve through which grease is pumped to the bearings.

(*Continued on page* 20)

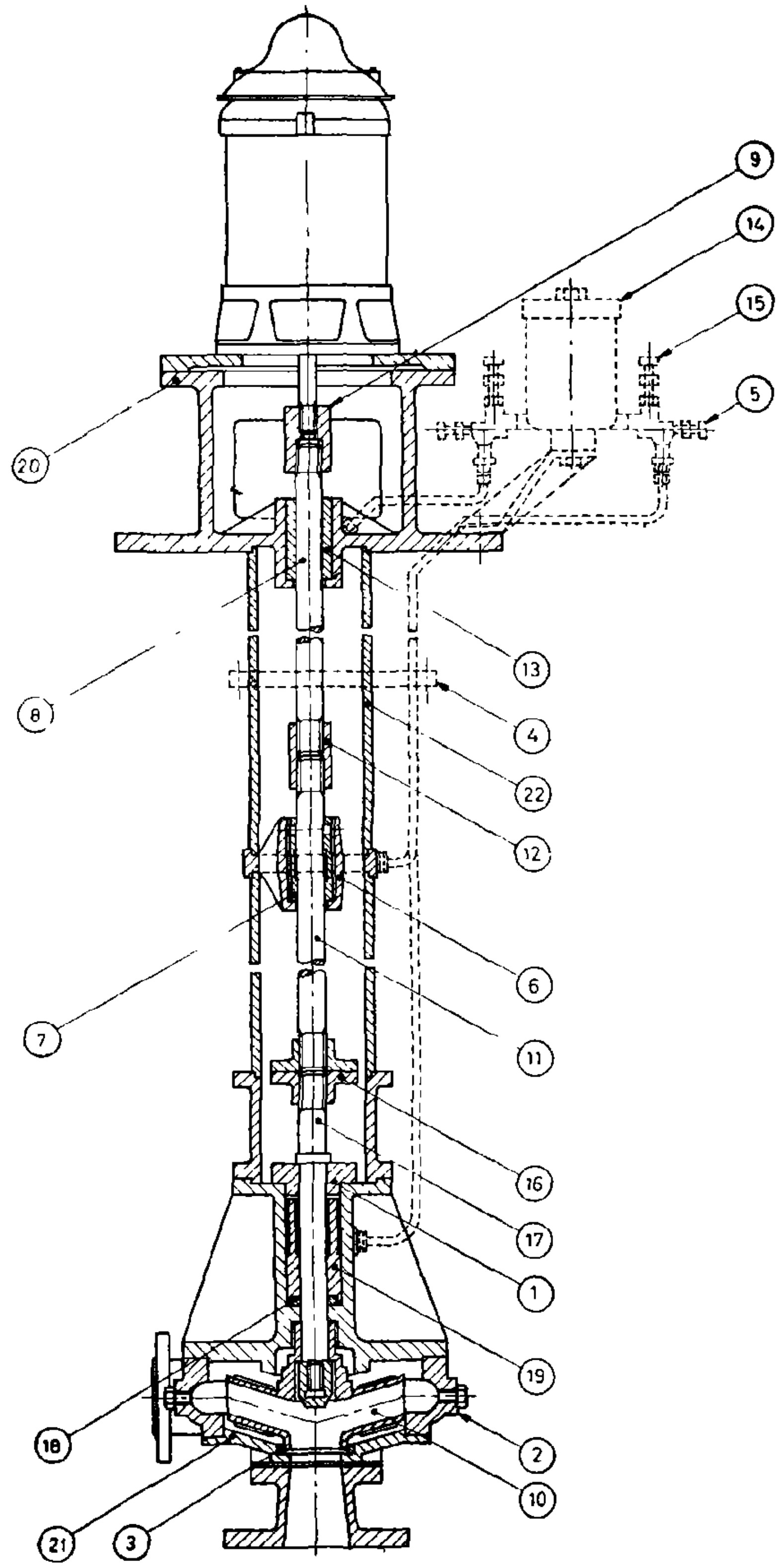


FIG. 14 TYPICAL ILLUSTRATION OF SPECIAL PURPOSE VERTICAL VOLUTE PUMP

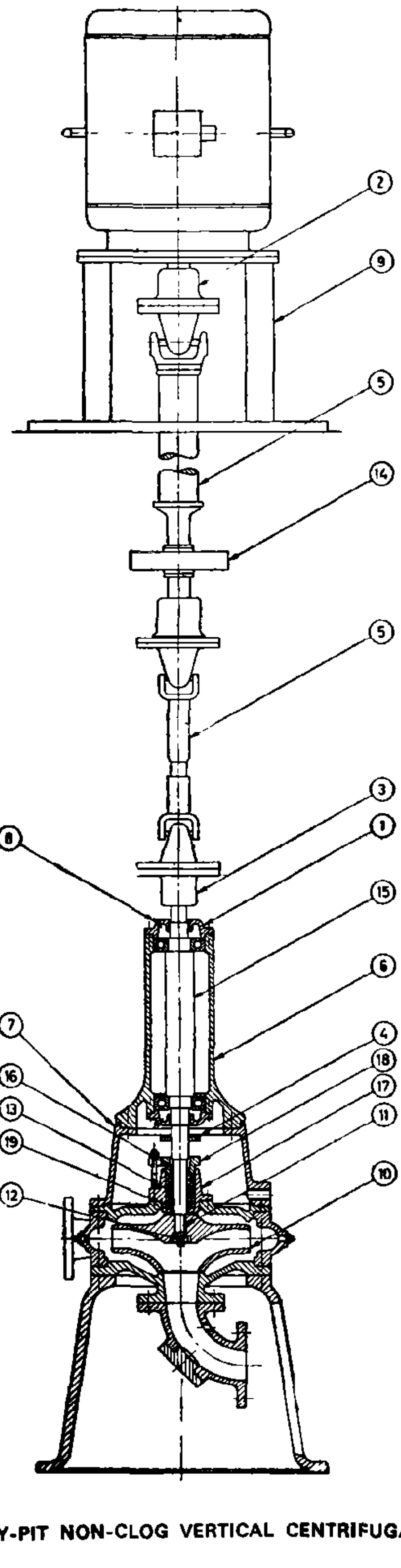


FIG. 15 DRY-PIT NON-CLOG VERTICAL CENTRIFUGAL PUMP

4.5 *Dry Self-Priming Centrifugal Pumps* — The names of the parts commonly used in connection with dry self-priming centrifugal pumps are listed in Table 6 (*see* Fig. 16).

TABLE 5 NOMENCLATURE OF PARTS COMMONLY USED IN DRY-PIT NON-CLOG VERTICAL CENTRIFUGAL PUMPS — *Contd*

Part No.	Name of Part	Brief Description and Function of Parts
9.	High ring base	A part functioning as a base for the motor.
10.	Impeller	A rotating element producing head
11.	Impeller key	A parallel sided element preventing the impeller from rotating relative to the shaft.
12.	Impeller nut	To secure the impeller on the shaft.
13.	Lantern ring	Sealing liquid is supplied through the lantern ring into the stuffing box.
14.	Plummer block	A housing for the bearings.
15.	Pump shaft	A shaft which holds the rotating impeller and transmits the motion.
16.	Shaft sleeve	A replaceable sleeve for protecting the shaft.
17.	Stuffing box	Used for sealing off liquid at discharge head along pump shaft. Acts also as a guide to pump shaft.
18.	Stuffing box gland	This compresses packing at discharge head and guides head shaft.
19.	Stuffing box packing	Used in stuffing box for sealing off liquid from discharge head.

TABLE 6 NOMENCLATURE OF PARTS COMMONLY USED IN DRY SELF-PRIMING CENTRIFUGAL PUMPS

(*Clauses* 4.0 *and* 4.5, *and* Fig 16)

Part No.	Name of Part	Brief Description and Function of Parts
1.	Bearing cover	A protective cover for the bearing.
2.	Bearing pedestal	A casting with supporting feet accommodating the bearing or bearings.
3.	Casing	A portion of the pump which houses the impeller and incorporates the volute.
4.	Casing ring	A stationary replaceable ring to protect the casing at running fit with the impeller ring or the impeller.
5.	Deflector	A device to protect bearings by slinging off stuffing box leakage.
6.	Grease nipple	A non-return valve through which grease is pumped to the bearing.
7.	Impeller	A rotating element producing head.
8.	Impeller key	A parallel sided piece used to prevent the impeller from rotating relative to the shaft.
9.	Impeller nut	To secure the impeller on the shaft.
10.	Mechanical seal, rotating element	A flexible device mounted on the shaft in the stuffing box and having lapped sealing face held against the stationary sealing face.
11.	Mechanical seal, stationary element	A sub-assembly consisting of one or more parts mounted on the stuffing box and having a lapped sealing face.
12.	Non-return valve housing	A housing for the non-return valve.
13.	Pump shaft	A shaft which holds the rotating impeller and transmits the power.

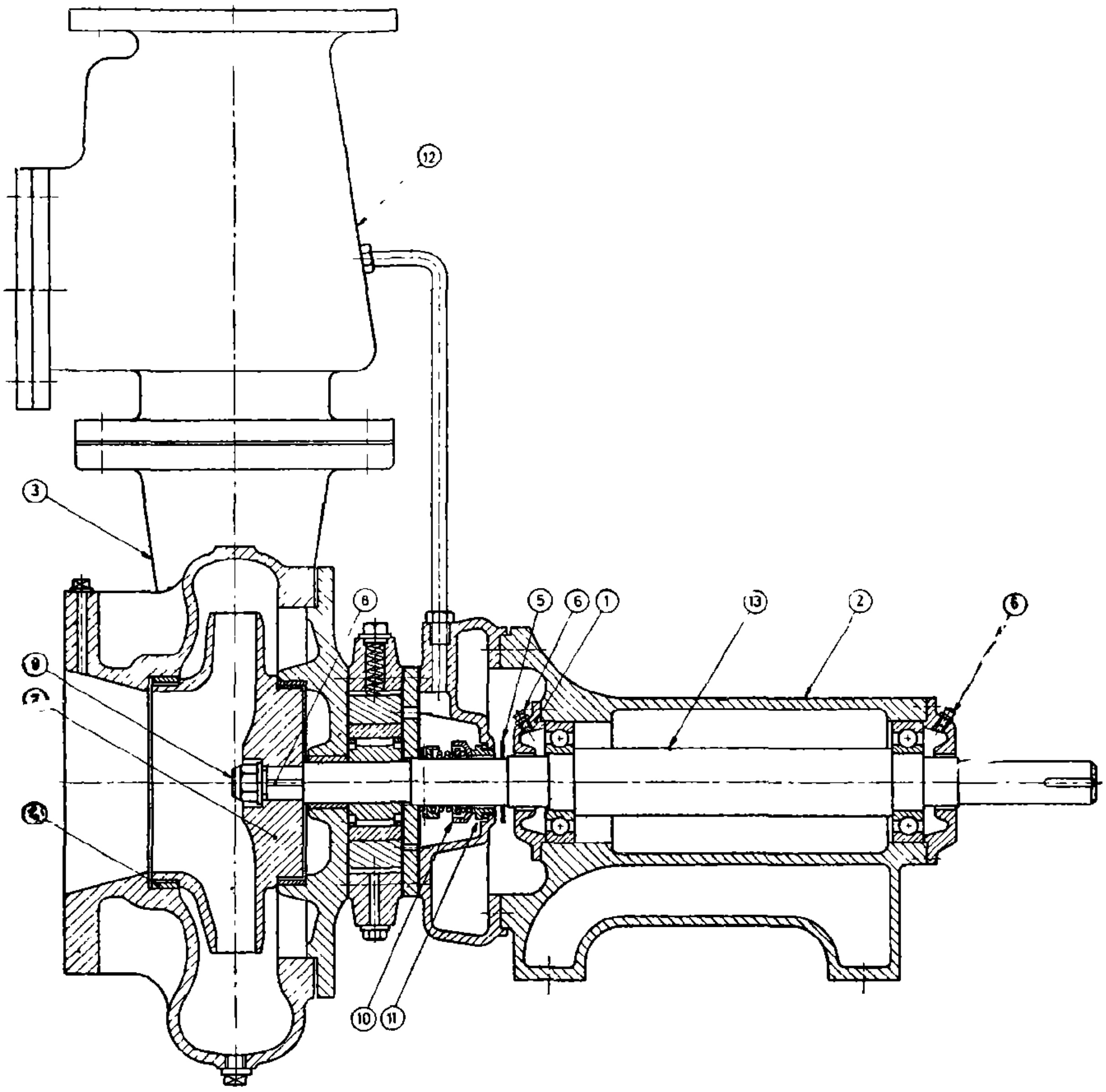


FIG. 16 NOMENCLATURE FOR DRY SELF-PRIMING CENTRIFUGAL PUMP

5. Material of Construction

5.1 The materials of construction for various parts of special purpose pumps coming in contact with the pumped liquid depend on the particular application. It is recognized that a number of materials of construction is available to meet the needs of any particular application. A few of the materials are listed below merely for the guidance of the manufacturer and the user. The list is not intended to be exhaustive. This list does not necessarily indicate that all the materials listed are equally effective in all environments. It merely indicates that each type of material has been satisfactorily applied in handling that liquid, under some, possibly all, conditions.

Wrought materials, such as shafts may be either of similar composition to the castings used, or suitable shaft protection should be provided against corrosion. Most of the parts are primarily castings.

The materials of construction for the various parts of pumps may be selected from one or more of the following. The material of construction recommended for the pumps for handling different liquids are given in Table 7:

Selection No.	*Material of Construction*	*Relevant Specification*
1.	Bronze fitted*	Grade V of IS : 318-1962 'Specification for leaded tin bronze ingots and castings (*revised*)'
2.	All iron	Grade 20 of IS : 210-1970 'Specification for grey iron castings (*second revision*)'
3.	All bronze	Grade V of IS : 318-1962
4.	All austenitic iron	Type 2 of IS : 2749-1964 'Specification for austenitic iron castings'
5.	All stainless steel	Designation 07Cr19Ni9MoZ of IS : 1570-1961 'Schedules for wrought steels for general engineering purposes'
6.	All monel metal	Composition: Nickel — 63 percent Copper — 30 percent Iron — 2 percent Manganese — 0·9 percent Silicon — 4 percent Tensile stress — 588 MN/m^2 Elongation on 5 *d* — 20 to 10 percent Brinell hardness — 275 to 300
7.	Rubber lined	†
8.	White iron	IS : 2107-1962 'Specification for malleable cast iron castings'
9.	Graphite	†
10.	Hastelloy	Composition: Nickel — 85 percent Silicon — 10 percent Copper — 3 percent
11.	Nickel cast iron	Composition: Nickel — 0·7 to 2 percent Iron — Remainder Tensile stress — 177 MN/m^2 *Specific gravity* — 7·3
12.	Alumina porcelain	Electrical porcelain containing approximately 50 percent alumina (Al_2O_3)
13.	Chlorimet 3	Composition: Nickel — 60 percent *Chromium* — 18 *percent* Molybdenum — 18 percent Iron, silicon and carbon — Remainder
14.	Antimonial lead (hard lead)	Composition: Lead — 94 percent Antimony — 6 percent
15.	High silicon cast iron (duriorn)	Composition: Silicon — 15 percent Iron, carbon and manganese — Remainder
16.	Ceramic (glass/stoneware)	†
17.	PVC (unplasticized)	†
18.	Polystyrene	†
19.	Glass lining	†

5.2 *Gaskets, Seals and Packings* — The gaskets, seals and packings, used in special purpose pumps, shall be suitably chosen so as to withstand the effect of liquid being pumped. This shall be selected generally in consultation with the manufacturer taking into account the end uses. Wherever possible, suitable mechanical seals are to be preferred to packings.

The recommended materials for seals for special purpose pumps may be selected from one or more of the following:

Selection No.	*Brief Description of Seals*
1.	Asbestos plaited yarn seal greased, graphited and lubricated

**Bronze Fitted Pumps* — The pumps in which the casing is of cast iron; the impeller, the casing ring, the impeller ring and shaft sleeves are of bronze, and the shaft is of steel.

†Wherever these and other materials not included in the list are required, they shall form the subject of a separate agreement between the supplier and the purchaser.

2. Asbestos plaited throughout yarn seal unlubricated
3. Asbestos steam seal greased, graphited and lubricated
4. Asbestos lubricated hard seal
5. Asbestos rubberized laminated seal
6. White metal foil seal crinkled lubricated asbestos yarn
7. Blue asbestos anti-acid seal non-metallic
8. Polytetrafluoroethylene (Teflon)
9. Cotton yarn (lubricated) seal
10. Mechanical seal

5.2.1 Seals recommended for various types of fluids handled are given in Table 7. Wherever possible, mechanical seals should be preferred to those given in the table.

TABLE 7 RECOMMENDED MATERIAL OF CONSTRUCTION AND STUFFING BOX PACKING FOR PUMPING VARIOUS FLUIDS (CAVITATION EFFECT INCLUDED)

Sl No.	Fluid	Formula	Condition of Liquid	Material Recommended	Packing Selection Number
1.	Acetaldehyde	CH_3CHO	Cold	1	7
2.	Acetate solvents	—	—	1,2,3,5,10,13	7
3.	Acid, acetic	CH_3COOH	Cold	5,10,13,15	7,10
4.	Acid, carboric	CO_2+H_2O	Aqueous	3	7,10
5.	Acid, hydrochloric	HCl	Dilute cold	6,7,9,12	7,10
6.	Acid, mine water	—	—	3,5,10,11,12	7,10
7.	Acid, mixed	—	Sulphuric nitrate	2,5,11,12	10
8.	Acid, nitric	HNO_3	Dilute	4,5,7,12,15	10
9.	Acid, benzoic	C_6H_5COOH	—	5,10,13	7,10
10.	Acid, hydrofluoric	HF	Anhydrous with hydrocarbon	6	10
11.	Acid, sulphuric	H_2SO_4	65/93%<175°C	2,5,6,10,11	7,10
12.	Acid, sulphuric	H_2SO_4	65/93%>175°C	2,5,6,10,11,12,13,14,15	7,10
13.	Acid, sulphuric (oleum)	$H_2SO_4+SO_3$	Fuming	—	10
14.	Acid, sulphuric	H_2SO_4	10 percent	5,6,10,11,12,13,14,15	7
15.	Acid, sulphurous	H_2SO_3	—	3,5,10,13,14	10
16.	Acid, tan	—	—	3,5,6,10,13	7,10
17.	Alcohols	—	—	1,3,5	10
18.	Aluminium sulphate	$Al_2(SO_4)_3$	Aqueous soln (pure)	5,6,11,14,15	5
19.	Ammonia aqua	NH_4OH	—	2,12	5
20.	Ammonium chloride	NH_4Cl	Aqueous soln	5,6,11	5
21.	Ammonium nitrate	NH_4NO_3	Aqueous soln	2,5,4,6,11	5
22.	Ammonium phosphate, dibasic	$(NH_4)_2HPO_4$	Aqueous soln	1,2,5,6,11,13	3,5
23.	Ammonium sulphate	$(NH_4)_2SO_4$	Aqueous soln	2,4,5,11	5
24.	Asphalts	—	—	1,5	7
25.	Barium nitrate	$Ba(NO_3)_2$	Aqueous soln	2,5,6,11	—
26.	Beer	—	—	3,5	4
27.	Beet juice	—	—	3,5	4
28.	Beet pulp	—	—	1,2,3,5,10,11,13	4
29.	Benzene	C_6H_6	—	1,2,5	10
30.	Benzol	—	—	1,2,5	10
31.	Brine, alkali	—	—	2,5	—
32.	Brine, acidic	—	—	5,7	—
33.	Brine, chilling	—	—	2	—
34.	Brine, sea water	—	—	1,2,3,4,5	4
35.	Butane	C_4H_{10}	—	1,2	10
36.	Calcium chloride aqueous soln	$CaCl_2$	pH>8	1	4

(Continued)

TABLE 7 RECOMMENDED MATERIAL OF CONSTRUCTION AND STUFFING BOX PACKING FOR PUMPING VARIOUS FLUIDS (CAVITATION EFFECT INCLUDED) — *Contd*

Sl No.	Fluid	Formula	Condition of Liquid	Material Recommended	Packing Selection Number
37.	Calcium chloride Aqueous soln	$CaCl_2$	$pH<8$	3,4,5,6	4
38.	Calcium magnesium chloride	—	Aqueous	3,4,5,6	4
39.	Calcium sodium chloride	—	Aqueous	3,4,5,6	4
40.	Calcium hypochlorite	$Ca(OCl)_2$	Aqueous	1,5,6,15	4
41.	Cane juice	—	—	1,3,4	4
42.	Carbon bisulphide	CS_2	—	2	3
43.	Carbon tetrachloride	CCl_4	Aqueous soln	3,5	3
44.	Chloro benzene	C_6H_5Cl	—	1,2,3,4,5	10
45.	Chloroform	$CHCl_3$	—	3,5,6,10,13	10
46.	Cellulose acetate	—	Aqueous	5,6	4
47.	Copper ammonium acetate	—	Aqueous	1,5,10,13	4
48	Copper chloride	$CuCl_2$	Cupric aqueous	6,7,9,15	4
49.	Enamel	—	—	1	4
50.	Ethane	C_2H_6	—	1,2	10
51.	Ethylene chloride (dichloride)	$C_2H_4Cl_2$	Cold	3,5,6	10
52.	Ferrous sulphate	$FeSO_4$	Aqueous	5,6,14,15	4
53.	Fruit juices	—	—	3,5,6,10,13	2
54.	Gasoline	—	—	1,2,5	3,10
55.	Glycerol (Glycerine)	$C_3H_5(OH)_3$	—	1,2,3,5	3
56.	Hexane	C_6H_{14}	—	1,2	10
57.	Heptane	C_7H_{16}	—	1,2	10
58.	Hydrogen peroxide	H_2O_2	Aqueous	5,10,13	10
59.	Jar	—	Hot	1	—
60.	Janning liquors	—	—	3,5,6,10,13,15	7
61.	Lime water (milk of lime)	$Ca(OH)_2$	—	2,5,13	4
62.	Liquor, pulp mill black	—	—	1,2,4,5,6,11	4,10
63.	Liquor, pulp mill green	—	—	1,2,4,5,6,11	4,10
64.	Liquor, pulp mill white	—	—	1,2,4,5,6,11	4
65.	Liquor, pulp mill pink	—	—	1,2,4,5,6,11	4,10
66.	Lithium chloride	LiCl	Aqueous	1	—
67.	Manganese chloride	$MnCl_2$	Aqueous	3,5,10,13,15	4
68.	Milk	—	—	5	2,10
69.	Molasses	—	—	1,3,5	4
70.	Oil, cold tar	—	—	1,2,5,10,13	4,7
71.	Oil, coconut	—	—	1,2,3,5,6,11	4
72.	Oil, creosote	—	—	1,2	4
73.	Oil, crude	—	Cold or hot	1,2	4
74.	Oil, kerosene	—	—	1,2,5	4,10
75.	Oil, linseed	—	—	1,2,3,5,6,10,13	9
76.	Oil, lubricating	—	—	1,2	9
77.	Oil, mineral	—	—	1,2	9
78.	Oil, olive	—	—	1,2	9
79.	Oil, palm	—	—	1,2,3,5,6,11	9
80.	Oil, quenching	—	—	1,2	9
81.	Oil, rapeseed	—	—	3,5,6,10,13	9
82.	Oil, soyabean	—	—	1,2,3,5,6,10,13	9
83.	Oil, turpentine	—	—	1,2	10
84.	Oil, paraffin	—	Hot or cold	1,2	4
85.	Oil, petroleum ether	—	—	1,2,5	10
86.	Pentane	C_5H_{12}	—	1,2	10
87.	Potash	—	Plant liquor	3,4,5,6,11	6
88.	Potash alum	$Al_2(SO_4)_3 K_2SO_4 24H_{20}$	Aqueous	3,4,6,11	6
89.	Potassium-carbonate	K_2CO_3	Aqueous	1,2	6
90.	Potassium chlorate	$KClO_3$	Aqueous	5,10,13,15	6
91.	Potassium hydroxide	KOH	Aqueous	2,4,5,6,12	6
92.	Potassium nitrate	KNO_3	Aqueous	1,5,10,13	6

(Continued)

TABLE 7 RECOMMENDED MATERIAL OF CONSTRUCTION AND STUFFING BOX PACKING FOR PUMPING VARIOUS FLUIDS (CAVITATION EFFECT INCLUDED) — *Contd*

Sl No.	Fluid	Formula	Condition of Liquid	Material Recommended	Packing Selection Number
93	Propane	C_3H_8	Aqueous	1,2	10
94.	Pyridine	C_5H_5N	—	5	6
95.	Sewage	—	—	1,2,3,4	9
96.	Silver nitrate	$AgNO_3$	Aqueous	5,10,13,15	9
97.	Slop, brewery	—	—	1,2,3	4
98.	Slop, distillers	—	—	3,5	4
99.	Soap, liquor	—	—	4,5	4
100.	Soda ash	Na_2CO_3	Cold	2	4
101	Soda ash	Na_2CO_3	Hot	4,5,6	4
102.	Sodium bicarbonate	$NaHCO_3$	Aqueous soln	2,4,5	
103.	Sodium chloride	NaCl	<3 1% Cold	1,3,4	4
104	Sodium chloride	NaCl	>3 1% Cold	3,4,5,6,10,13	4
105.	Sodium chloride	NaCl	>3·2% Hot	5,6,15	4,10
106.	Sodium hydroxide	NaOH	Aqueous soln	1,2,4,5,6,10,12	5
107.	Sodium silicate	Na_2SiO_3	—	1	4
108.	Sodium sulphate	Na_2SO_4	Aqueous soln	3,5,12	5
109.	Starch	$(C_6H_{10}O_5)$	—	1,2,3,5	3
110.	Sugar	—	Aqueous soln	3,4,5,10,13	3
111.	Vegetable juices	—	—	3,5,6,10,15	4
112.	Vinegar	—	—	3,5,10,11,13,15	7
113.	Water boiler feed	—	Not evaporated *p*H 8 5	2,5	1
114.	Water, high make up	—	*p*H 8 5	1	9
115.	Water, low make up	—	Evaporated	5,6	9
116	Water, chlorinated	—	—	7	1
117.	Water, distilled	—	High purity	3,5,7	9
118.	Water, distilled	—	—	1,3,7	9
119.	Water, fresh	—	Condensate	1,2,3	9
120	White water	—	Paper mills	1,2,3	4
121	Wood pulp	—	Stock	1,2,3	4
122.	Zinc sulphate	$ZnSO_4$	Aqueous soln	3,5,11	7

6. Classification

6.1 *Classes* — The pumps covered by this standard shall be generally classified into the following classes

6.1.1 *Radial flow pumps* — Pumps in which the head is developed by the action of centrifugal force upon liquid which enters the impeller axially at the centre and flows radially to the periphery (*see* Fig. 17)

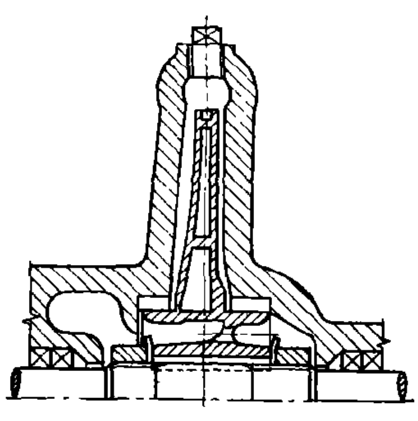


FIG. 17 RADIAL FLOW PUMP

Pumps in this class with single suction impellers usually have a specific speed (n_q) (*see* **3.8**) below 300 and with double suction impellers a specific speed below 400.

6.1.2 *Mixed flow pumps* — Pumps in which the head is developed partly by the action of centrifugal force and partly by axial propulsion as a result of which the fluid entering the impeller axially at the centre is discharged in an angular direction (*see* Fig. 18).

Pumps in this class with single suction impellers have usually a specific speed (n_q) 300 to 650 and with double suction impellers, a specific speed from 400 to 850.

6.1.3 *Axial flow pump* — A pump in which the head is developed by the propelling or lifting action of the vanes on the liquid which enters the impeller axially and discharges axially (*see* Fig 19).

Pumps of this type with a single inlet impeller usually have a specific speed greater than 900.

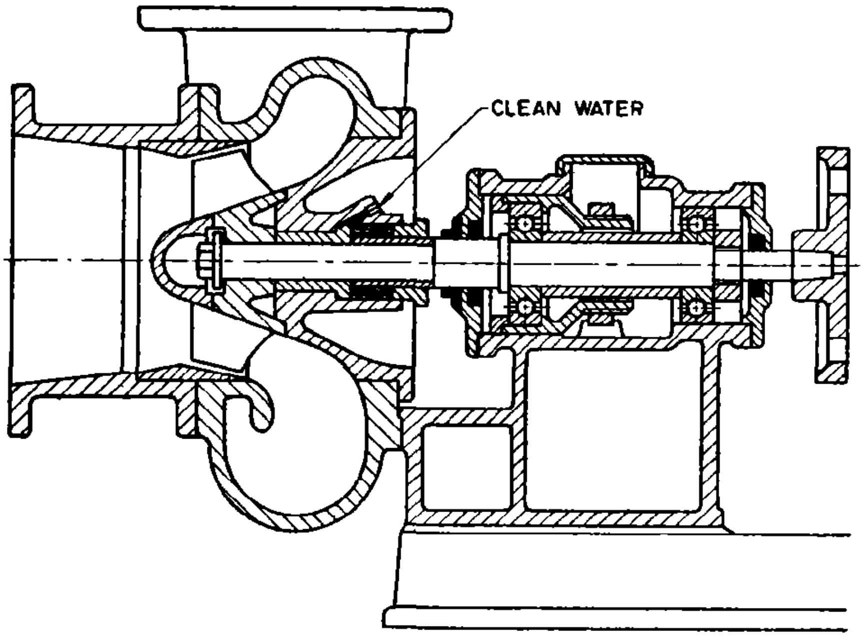


FIG 18 MIXED FLOW PUMP

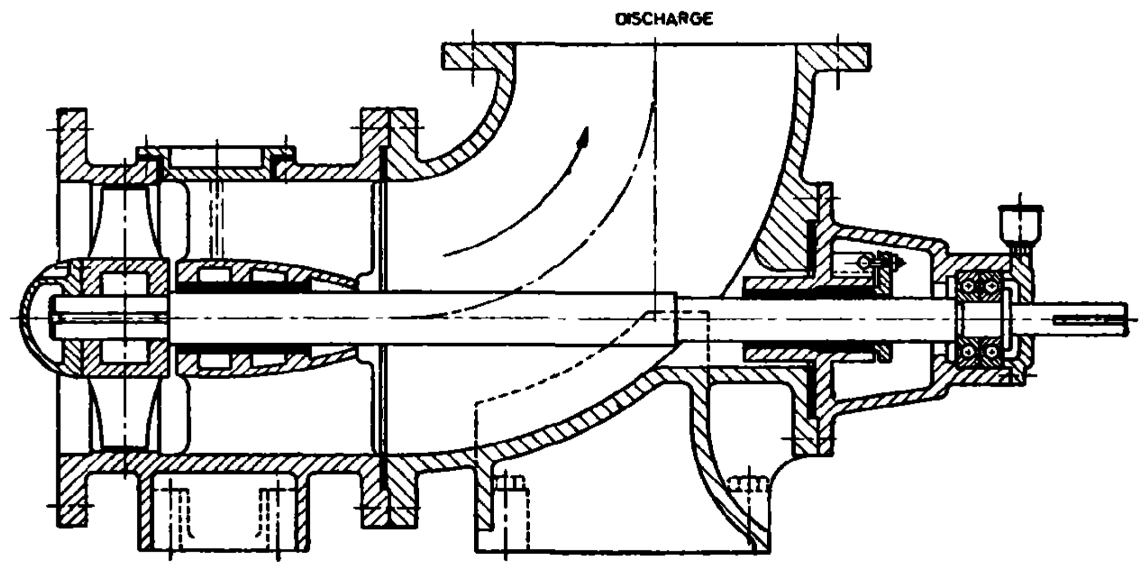


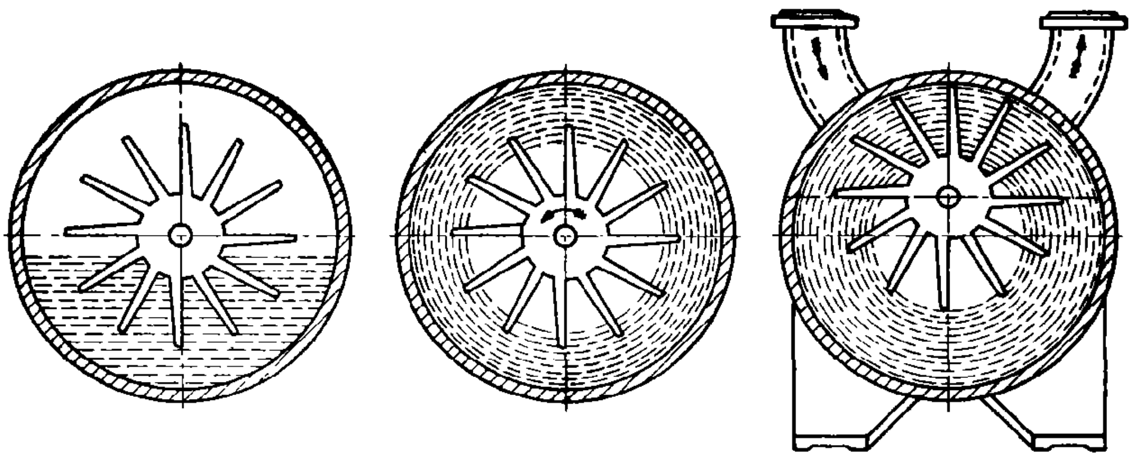
FIG. 19 AXIAL FLOW PUMP

6.1.4 *Rotary positive displacement pump, liquid ring type* — A pump in which the head is developed by running the impeller in an eccentric position related to the auxiliary liquid which rotates in concentric alignment with the casing. The liquid is forced in and out of the impeller cells rather like a piston thus creating pressure or vacuum (*see* Fig. 20).

6.1.5 *Regenerative pumps, side-channel type* — A pump in which the head is developed by re-circulating the liquid through a series of rotating vanes (*see* Fig. 21A). The impeller of this type of pump is usually solid, one piece disc with vanes formed on one or both of its sides at the periphery (*see* Fig. 21B).

Pumps in this class usually have a specific speed less than 500.

6.2 *Types* — The pumps covered in this standard shall be classified into different types depending upon the following characteristics.



Auxiliary Liquid at Rest

Formation of Liquid Ring During Operation with Concentric Impeller Arrangement

Formation of Liquid Ring During Operation with Eccentric Impeller Arrangement

FIG. 20 ROTARY POSITIVE DISPLACEMENT PUMP, LIQUID RING TYPE

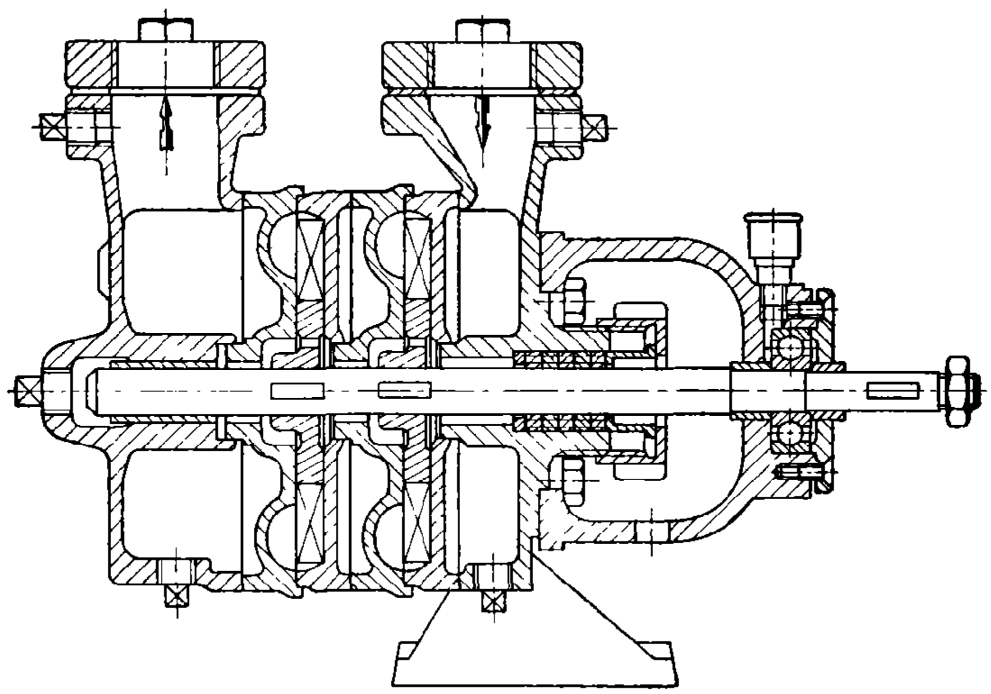


FIG. 21A REGENERATING PUMP (SIDE CHANNEL PUMP)

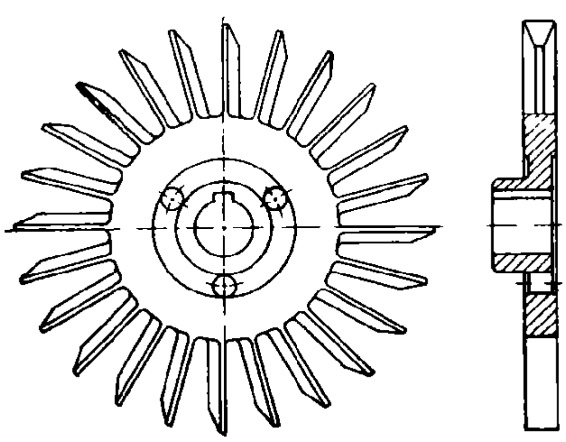


FIG. 21B IMPELLER FOR REGENERATING PUMP

6.2.1 *Number of stages*

a) *Single stage pumps* — pumps in which the total head is developed by one impeller.

b) *Multi-stage pumps* — pumps in which the total head is developed by more than one impeller

6.2.2 *Type of inlet*

a) *Single suction pumps* — pumps equipped with one or more single suction impellers (*see* Fig 22).

b) *Double suction pumps* — pumps equipped with one or more double suction impellers (*see* Fig. 23).

6.2.3 *Type of casing*

a) *Hydraulic design*

1) *Volute pumps* — pumps in which the velocity head is converted into pressure head in the casing made in the form of a spiral or a volute.

2) *Diffuser pumps* — pumps equipped with diffuser vanes which convert the velocity head into pressure head.

b) *Mechanical construction*

1) *Integral casing pumps* — pumps equipped with a casing made in a single piece.

2) *Horizontally split casing pumps* — pumps equipped with a casing split on the horizontal centre line.

3) *Vertically split casing pumps* — pumps equipped with a casing split on the vertical centre line.

4) *Diagonally split casing pumps* — pumps equipped with a casing split diagonally.

5) *Segmented casing pumps* — pumps equipped with a casing made up of segments. These may be either of the band type for multipurpose pumps or of the bowl type for turbine pumps.

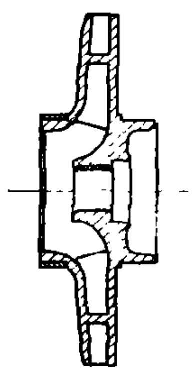


FIG. 22 SINGLE SUCTION IMPELLER

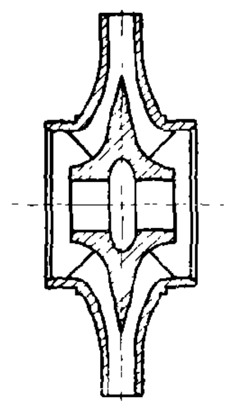


FIG. 23 DOUBLE SUCTION IMPELLER

7. Direction of Rotation

7.1 The direction of rotation of pumps is designated clockwise or counter-clockwise as observed when looking at the pumps shaft from the driving end (*see* Fig 24).

7.2 The direction of rotation shall be clearly marked either by incorporating it in the casing or by a separate metal plate arrow securely fitted to the casing.

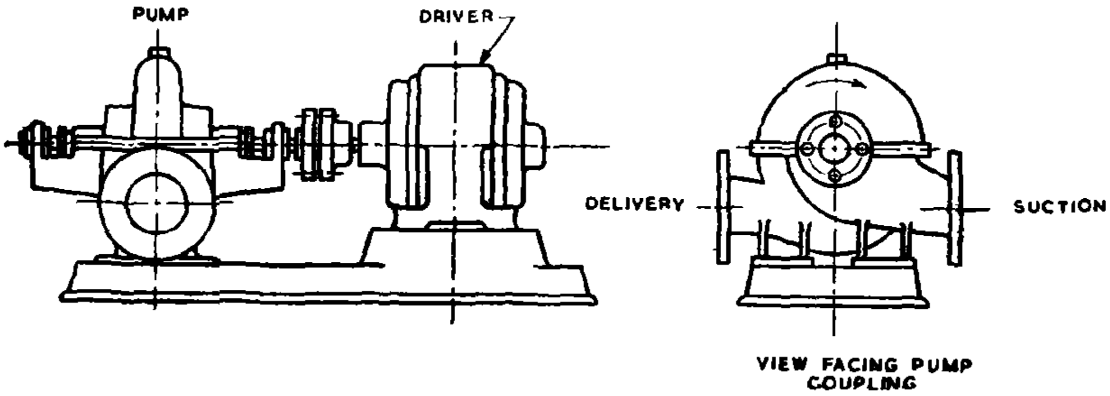


FIG. 24 DIRECTION OF ROTATION

8. Accessories

8.1 *Essential Accessories* — The following shall constitute the essential accessories:

a) Oil level indicator for oil lubricated bearings,
b) Non-reversible ratchet arrangement for vertical turbine pumps only,
c) Oil lubricator if the pump is oil lubricated, and
d) Grease cup for grease lubricated bearings.

8.2 *Optional Accessories* — The following shall constitute the optional accessories and shall be supplied subject to agreement between the manufacturer and the purchaser:

a) Flexible coupling or pulleys,
b) Pressure and vacuum gauges, with cock,
c) Prelubricating tank,
d) Footvalve with strainer,
e) Reflux valve,
f) Sluice valve,
g) Priming funnel with separate or integral air cock,
h) Test cock,
j) Float switches,
k) Base plate,
m) Tools,
n) Foundation bolts and nuts,
p) Companion flange,
q) A pair of column pipe clamps, and shaft clamps, and
r) Pressure relief valve.

9. Suction Limitations

9.1 Among the more important factors affecting the operation of a centrifugal pump are the suction conditions. Abnormally high suction lifts beyond the suction rating of the pump usually cause considerable reductions in capacity, head and efficiency often leading to serious trouble such as vibration and cavitation.

9.2 Cavitation can be described as the condition existing in flowing liquids when the pressure at any point falls below the vapour pressure of the liquid at the prevailing temperature. Some of the liquid flashes into vapour and bubbles of the vapour are carried along with the liquid. If this happens in the suction area of a centrifugal pump or within the entrance of the impellers, the bubbles are carried into the impeller and undergo an increase in pressure and, therefore, condense and finally collapse.

9.2.1 *Effects of cavitation* — The effects of cavitation are:

a) damage to material,
b) cavitation noise,
c) vibration due to the collapse of the bubble, and
d) deterioration in performance of the pump.

10. Factors Affecting Pump Performance

10.0 The following factors are to be considered from the performance point of view of rotodynamic pumps handling various types of liquids:

a) Specific gravity,
b) Viscosity,
c) Temperature,
d) Vapour pressure, and
e) Percentage of solids.

10.1 *Effect of Specific Gravity*

10.1.1 The pump develops the same head in metre of liquid independent of specific gravity and, therefore, the pressure in kg/cm^2 is proportional to the specific gravity.

10.1.2 The pump delivers the same quantity by volume independent of specific gravity, but the quantity by weight will be proportional to the specific gravity.

10.1.3 The efficiency is unaffected by the specific gravity of the liquid pumped, but the power absorbed is in direct proportion to the specific gravity.

10.1.4 The permissible suction lift varies with specific gravity. The height of a column of a liquid corresponding to the atmospheric pressure is inversely proportional to the specific gravity and the suction lift will vary accordingly.

10.2 *Effects of Viscosity*

10.2.1 Viscosity reduces the capacity and head.

10.2.2 Viscosity increases the power requirement due to disc friction losses involved and consequently lowers the efficiency.

10.2.3 Viscosity affects the suction lift of the pump.

10.2.4 The standard performance figures for a pump are with respect to water. In order to get the corresponding performance figures when handling a liquid of known viscosity some corrections have to be applied. The correction factors given here are to be applied for viscosity values up to 240 centipoise, as normally the rotodynamic pump is not to be recommended for liquids with higher viscosities.

10.2.5 The performance of a rotodynamic pump when handling viscous liquids may be determined, if its performance on water is known. The performance correction chart for viscous liquids is given in Fig. 25. The chart may also be used as an aid in selecting the pumps for given applications. The correction curves, therefore, are not exact for any particular pump but are to serve as a good guidance in the selection of pumps. The use of the performance correction chart and its limitations are explained in detail in **14**.

10.3 *Effects of Temperature*

10.3.1 Temperature affects specific gravity, and the performance curve, irrespective of vapour pressure, will be affected as enumerated in **10.1**.

10.3.2 Temperature affects the viscosity and the performance will be affected as enumerated in **10.2**

10.3.3 From this, it is clear that it is necessary to know the specific gravity and the viscosity of the liquid at the pumping temperature.

10.3.4 Temperature affects vapour pressure and hence the amount of $NPSH_r$ and $NPSH_a$.

10.3.5 Suction lift is to be reduced for higher altitudes at the rate of 1 15 m for every 1 000 m above mean sea level. The temperature correction should be obtained from steam tables.

10.4 *Effect of Vapour Pressure*

10.4.1 The vapour pressure of any liquid increases with an increase in temperature. Since the $NPSH_a$ to the pump is the suction head above the vapour pressure necessary to prevent cavitation, it follows that with an increase in temperature of the pumped liquid, suction head has to be increased so as to meet the $NPSH_r$ of the pump to ensure cavitation free flow.

10.4.2 For *NPSH* correction of hydrocarbons (*see* Fig. 26).

10.5 *Effect of Total Suction Lift*

10.5.1 The effect of total suction lift on a rotodynamic pump is related to its specific speed. The specific speed has been found to be very valuable criterion in determining the permissible maximum total suction lift or minimum suction head to avoid cavitation for various conditions of capacities, head and speed. For a given head and capacity, a pump of low specific speed will operate safely with a greater total suction lift than one of higher specific speed.

10.5.2 Figure 27 gives the total suction lift limits for double suction pumps of predominantly radial flow type having specific speed from 50 to 500 rev/min. Figure 28 gives the same for single suction mixed flow pumps of specific speed from 200 to 800 rev/min. The pumps may be selected within the limits shown in these curves with reasonable assurance of freedom from cavitation or the pumps should give the best efficiency point for a suction lift shown in these curves.

10.5.3 For determining the total suction lift for a single suction radial flow pump, its specific speed should be multiplied by $\sqrt{2}$ and then the curves referred to.

10.5.4 For double suction radial flow pumps, the total discharge including both suctions should be taken into account.

Example:

A single suction pump with shaft through eye of impeller has a total head of 30 m and specific speed

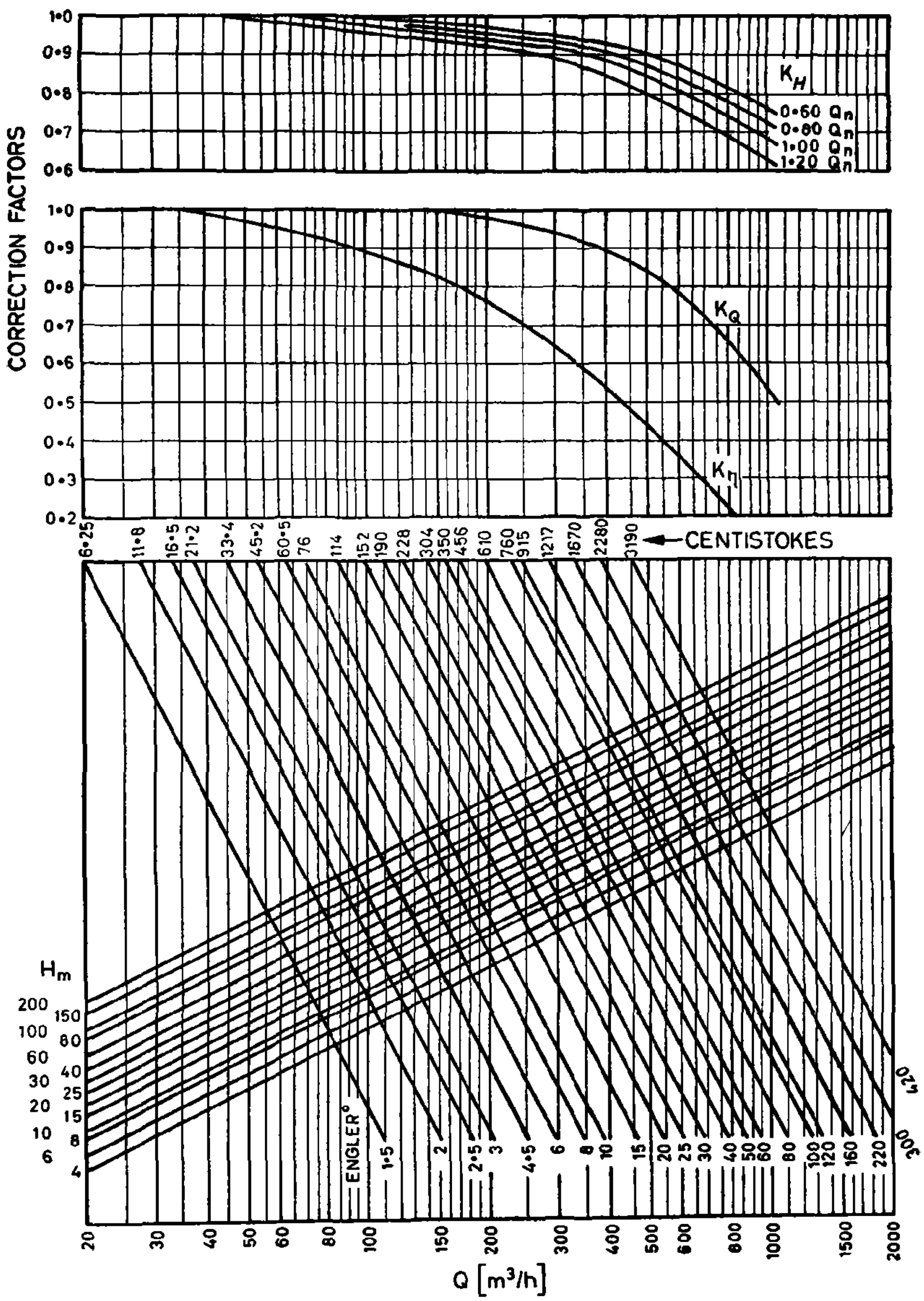


FIG. 25 PERFORMANCE CORRECTION CHART FOR VISCOUS LIQUIDS

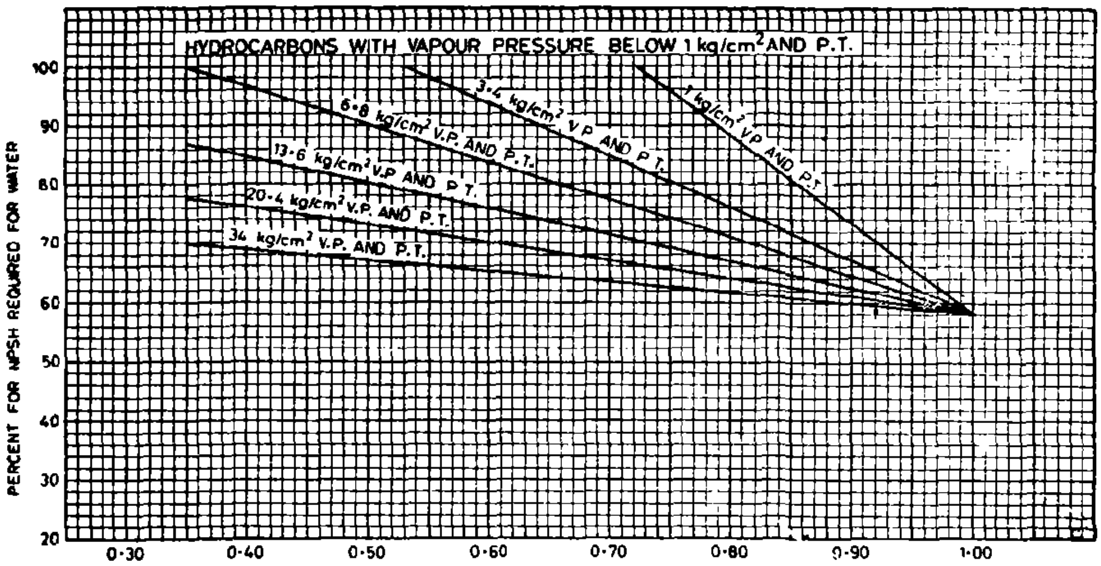


FIG. 26 NPSH CORRECTION CHART FOR HYDROCARBONS (NOT TO BE USED FOR OTHER LIQUIDS)

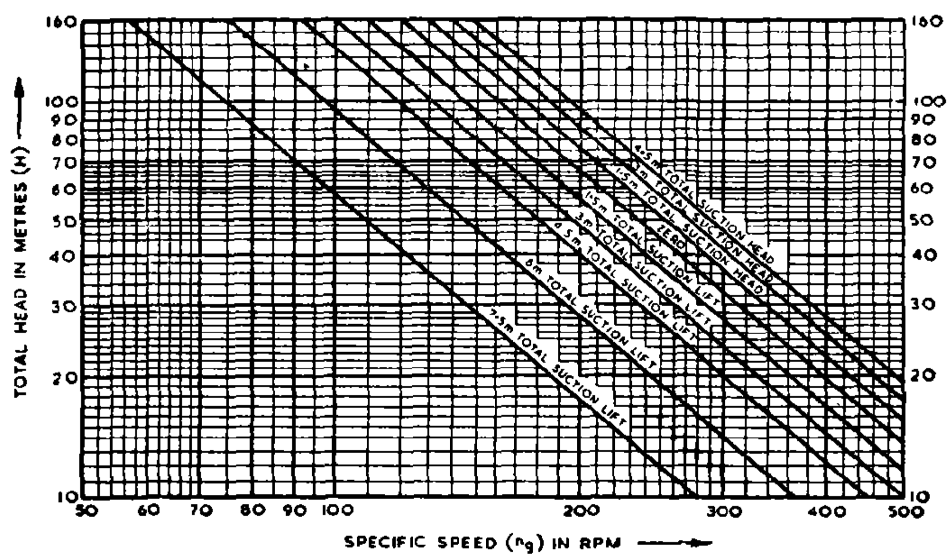


FIG. 27 SUCTION LIMIT CURVES FOR SINGLE STAGE, SINGLE AND DOUBLE SUCTION PUMPS

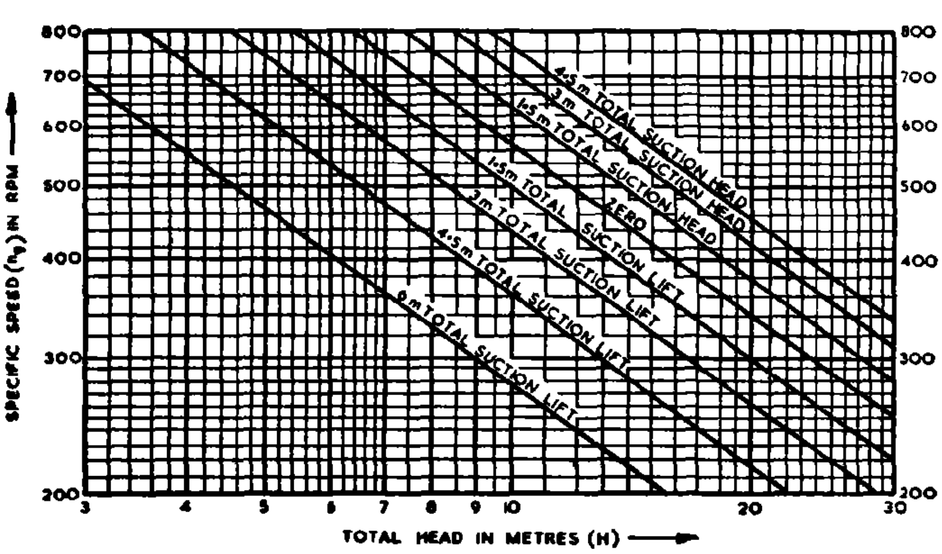


FIG. 28 SUCTION LIMIT CURVES FOR SINGLE SUCTION MIXED FLOW PUMPS

of 135 rev/min. What is the maximum allowable total suction lift to avoid danger of cavitation?
$\sqrt{2} \times$ specific speed $= \sqrt{2} \times 135 = 192$

The point of intersection of the vertical line (*see* Fig. 27) from 192 with the horizontal line from 30 m head, lies on total suction lift line of 6 m.

The total suction lift should not exceed this value.

11. Information to be Supplied by the Purchaser

11.1 When enquiring or ordering pumps, the user shall furnish the following information to the supplier:

a) *Pump application:*
   1) Altitude at site.
   2) Ambient temperature.
   3) If the pump is to work in parallel or in series with other pumps, detailed sketch of the installation with performance and other details of other pumps should be given.
   4) Number of working hours per day: .. .. Continuous/Intermittent. If intermittent, how often is the pump started or stopped.

b) *Liquid handled:*
   1) Liquid to be pumped,
      Trade name, if any.
   2) Chemical composition.
   3) Whether metal contamination is undesirable. If so, what percentage of element (Fe, Cu, Ni, Co) is permissible.
   4) *Nature* — Acidic/Alkaline/Neutral, *p*H value.
   5) If any gas or air is dissolved, details to be given. If paper pulp is to be handled, whether it is mechanical ground wood pulp or chemical pulp to be specified with its consistency.

	Maximum	*Normal*	*Minimum*
6) Working temp in °C			
7) Viscosity SSU/cSt			
8) Specific gravity			
9) Vapour pressure (indicate unit)			

   10) If any solids are present:
      i) Quantity, percent by weight
      ii) Shape and size of the largest piece in mm
   11) Character: Pulpy/Gritty/Hard/Soft.

c) *Number of pumps required.*

d) *Pump operating conditions:*
   1) Total capacity in litres per second.
   2) Capacity of each pump in litres per second.
   3) Total head (including friction losses) in metres.
   4) If the total head is not known (refer to the figure No. given or attach a figure), then the details of the following shall be provided:
      i) Static suction lift/positive suction head in metres.
      ii) Static delivery head in metres.
      iii) *If the pressure in the suction vessel and delivery tank are other than atmospheric:*
         Pressure in the suction vessel in kgf/cm².
         Pressure in the delivery tank in kgf/cm².
         Pipe material; Condition: New/Used.
         Suction pipe dia (d_s) in mm; Length (l_s) in metres.
         Delivery pipe dia (d_d) in mm; Length (l_d) in metres.

e) *Pipe fittings:*

Side / *Item*	*Suction* *Size No.*	*Delivery* *Size No.*
Foot valve		
Sluice valve		
Non-return valve		
Bend		
Tee		
Elbow		

f) *Prime mover details:*

1) Do you require a prime mover? Yes/No.

2) Electric motor drive.

i) *Type of drive* — Direct or indirect through pulley or gear, whether mounted on a common base plate or separately

ii) Type of current ac/dc, Phase single/three.

iii) Frequency in Hz

iv) Voltage

v) Rating in kW

vi) *Enclosure* — totally enclosed/drip-proof/flameproof/explosion proof, etc.

3) If other source of power is used, give full details

4) Special features required, if any, should be given

g) *Stuffing box seal arrangement required*

h) If any other pump is already in use, following information to be given.

1) Material of construction:

i) Delivery casing

ii) Shaft

iii) Impeller.

iv) Shaft sleeves

v) Gland.

2) Arrangement of stuffing box seal

3) Service life in months.

4) In case of trouble, which parts were affected

5) What was the nature of trouble — corrosion/erosion/galvanic action/stray current

11.1.1 *Clarification on the above information* — A few items in the above information will need further clarification These clarifications are given below with reference numbers as given in the above information sheet

11.1.1.1 *Operating head range* [*see* **11.1** (a) (3)] — Whenever two or more pumps are involved, a curve showing the system-head, capacity characteristics is necessary to determine the operating head range For operating head range specification, reduction in friction head losses with decreased capacity resulting from an increased static head and the reverse with increased capacity resulting from a decreased static head shall be considered

Size limitations imposed by transaction through the mine shaft are to be studied

11.1.1.2 *Type of installation* — It may be horizontal or vertical If vertical in dry or wet pit with enclosed shaft construction, the centre-line of the suction pipe (if fixed by existing construction), and the motor supporting floor should be defined with details In case of open shaft construction if the vertical distance is such that steady bearings may be required for the transmission shafting, location of bearing supporting beams or of floors, if fixed by some local conditions, should be described This, with the information as to water levels in the suction pump, will permit to select a proper length of transmission shaft

11.1.1.3 *Nature of liquid* [*see* **11.1** (b) (4)] — Acidic or alkaline, concentration of the solution, and impurities present in the liquid to be handled, if any, are to be indicated The last item is of paramount importance, as experience has shown that presence of various impurities has a marked effect on the relative resistance to corrosion of various pulp materials

11.1.1.4 *Size of solids* [*see* **11.1** (b) (10)] — If the sewage is not screened or commutated, it is desirable that sewage pumps that are on straight domestic sewage service be capable of passing 65 mm solids On storm water or combined domestic and storm water systems, larger solids can be expected. In such cases it is usual to protect the pumps by employing trash bars of proper size on the suction side. A pump design capable of passing very large solids for the capacity involved is not desirable as it often forces the manufacturer to offer larger, more expensive and less efficient pumps than if a more reasonable smaller size solid limitation was involved.

11.1.1.5 Capacity at average or design head with limitations, if any, at other head [*see* **11.1** (d) (2)].

Unnecessary restrictions of capacities at other than design heads may require special designs with unnecessary high cost.

11.1.1.6 *Suction conditions* [*see* **11.1** (d) (4)] — Full information is required on how the suction lift varies with total head, capacity or number of units in service together with an explanatory sketch.

Methods preferred to prime pump, if there is a suction lift, are to be considered. If necessary, change the pump location to arrange for operation under submergence if suction lift is impracticable or to reduce positive suction head if sealing stuffing box is impracticable.

11.1.1.7 *Special considerations for the electric motors* [*see* **11.1** (f)] — Description of special insulation or enclosure necessary for the electric motors, if any, should be indicated

11.1.1.8 *Special sealing requirements* [*see* **11.1** (g)] — Local practice with respect to packing, sealing methods and effect of dilution by sealing liquids should be taken into account.

11.1.1.9 *Past experience* [*see* **11.1** (h)] — Past experience with various materials or combination of materials and liquids handled should be mentioned In many cases, dissimilar materials of the reservoir from which the liquid is drawn and of the pump itself set up a galvanic action which may be harmful to one or the other material, thereby requiring proper isolating precautions

12. Information to be Furnished by the Supplier

12.1 The following information shall be furnished by the supplier

a) Performance with clear cold fresh water:
   1) Pump type
   2) Discharge in litres/second
   3) Head in metres
   4) Suction pipe size in mm dia
   5) Delivery pipe size in mm dia
   6) Power at shaft in kW
   7) Speed in rev/min

b) Performance with the liquid calculated as
   1) Discharge in litres/second
   2) Head in metres
   3) Power at shaft speed in kW corresponding to
      i) Pumping temperature in °C
      ii) Viscosity in cSt
      iii) *NPSH* in metres
      iv) Specific gravity

c) Required *NPSH* in metres

d) Performance curves

e) Materials of construction of impeller, casing and shaft should be suitably indicated, if required

f) If the pumped liquid is gritty:
   1) Maximum solid size handling capacity in mm dia
   2) Permissible concentration, percent by weight

g) Recommended:
   1) Suction pipe size in mm dia
   2) Delivery pipe size in mm dia
   3) Weight of the pump in kg
   4) Any special instructions for installation, operation and maintenance including the use of special tools

h) Sealing arrangement

j) Recommended spares for 2 years' service

k) Prime mover. All information corresponding to the information sought by the customer

13. Pump Test

13.0 *Object* — Pump tests are made to determine the following:

a) The discharge against a specified head when running at a specified speed under a specified suction lift or head,

b) The power absorbed by the pump at the pump shaft (*BP*) under the above specified conditions, and

c) Efficiency of the pump under the above specified conditions.

13.1 *Sampling* — Ten percent of a production batch subject to a minimum of ten pumps shall be tested. However, if the production batch is less than ten then the entire batch shall be tested.

13.2 *Observations During Pump Test* — During the whole period of the pump test, careful observations shall be made in regard to the following:

a) Undue shock, hammering, vibrations or other mechanical defects;

b) Bearing temperature, which shall not exceed the limits specified by the manufacturer,

c) Lubrication of the bearings;

d) Operation of stuffing box and water sealing device;

e) Operation of the balancing device in multistage pumps, when provided; and
f) Any loss of discharge between the pump and the point of measurement of discharge.

13.3 The performance figures for a pump handling liquid shall be determined from the actual performance of the pump with the specified liquid where feasible. Under situations where it is not possible to conduct a test on the pump with the specified liquid, which is usually the case, the standard performance figures for a pump handling liquid shall be determined from the performance of the figures of the pump with respect to water. The water during the test shall have a characteristic as given under:

Turbidity, *Max*	50 ppm (silica scale)
Chlorides, *Max*	500 ppm
Total solids, *Max*	3 000 ppm
*p*H value	6·5 to 8·5
Specific gravity, *Max*	1·004
Temperature	30°C

13.3.1 In the case of vertical turbine pumps, the expected field performance may be obtained by running a laboratory test of the bowl assembly and then calculating the required performance. A typical laboratory test arrangement is illustrated in Fig. 29.

13.3.1.1 The order shall specify which of the following tests are required:

a) Laboratory test, and
b) Field test.

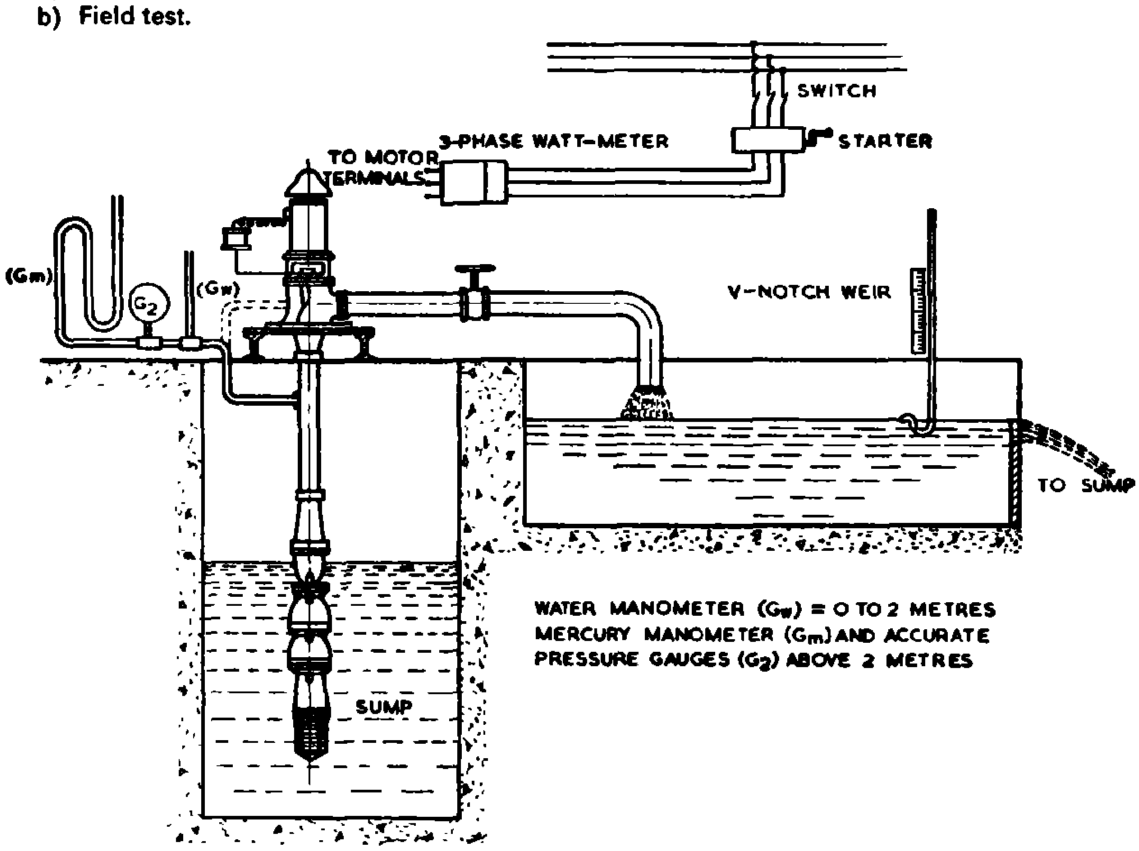


FIG. 29 LABORATORY TESTING ARRANGEMENT WITH POWER SUPPLY

13.3.2 The pump or bowl assembly shall be tested over the operating range covering from −25 percent to +25 percent of the specified head or up to the shut off head if it is less than +25 percent. A minimum of five readings, approximately equidistant on the characteristic curve including the operating points shall be taken. When the test is carried out at the specified speed, the actual speed during the test may vary within ±5 percent of the specified speed. The following similarity relations shall be used for finding the corresponding discharge, head and power at the specified speed from the actual readings:

a) $$\frac{\text{Actual discharge}}{\text{Specified discharge}} = \frac{\text{Actual speed}}{\text{Specified speed}}$$

b) $$\frac{\text{Actual head}}{\text{Specified head}} = \left(\frac{\text{Actual speed}}{\text{Specified speed}}\right)^2$$

c) $\dfrac{\text{Actual power}}{\text{Specified power}} = \left(\dfrac{\text{Actual speed}}{\text{Specified speed}}\right)^3$

It shall be noted that if the actual speed of rotation is within the limits given above the efficiency at the specified speed shall be taken the same as that at the actual speed. For large size pumps, however, the test may be carried out at a speed much lower than the specified speed (*see* **13.10** and **13.10.4**).

13.4 *Duration of Test*

13.4.1 The duration of test shall be sufficient to obtain accurate and consistent results. To verify the mechanical conditions of the pump, it shall be run continuously for not less than 1 hour.

13.5 Where a specification covers a range of performance, a minimum of five sets of readings shall be taken approximately equidistant on the characteristic curve.

13.6 *Measurement of Speed* — The speed shall be measured by a revolution counter or by an accurately calibrated tachometer, or by means of stroboscopic arrangement.

13.7 *Measurement of Discharge* — The discharge of the pump may be measured by means of volumetric tank, vee-notch, rectangular weir, standard venturi meter, pitot tube, orifice plate or a water meter. The method adopted for discharge measurement shall be suitable for the size of the pump, its duty and situation. The pump manufacturer shall, if required, give evidence of the proper calibration of the apparatus used.

13.7.1 *Volumetric method* — The water shall be pumped directly into one or more vessels of known or easily measurable capacity by volume or by weight, the time to fill such vessels carefully noted and the discharge calculated.

Note — This is the most satisfactory method of measurement for small flows, provided suitable means are available for quickly switching the full flow into and away from the measuring tank.

13.7.1.1 *Limits of accuracy* — The accuracy of the result by this method will depend on the length of time for which the flow is recorded, the accuracy of the stop-watch as well as the method of measuring the height of water in the tank of given cross section. Provided, every precaution is taken and the rise and fall is not less than 300 mm, this method will give discharge correct to within ± 1 percent

13.7.2 *Vee-notch*

13.7.2.1 The vee-notch provides a convenient method of measurement for discharges from 120 to 7 200 litres per minute. For small discharges, that is, from 120 to 2 400 litres per minute a half-90° vee-notch is preferred. The half-90° vee-notch has half the area of a 90° vee-notch, the distance across the top being equal to the vertical depth and the sides being symmetrical about the vertical axis. The discharge of water over a half-90° vee-notch is half that over a 90° vee-notch with the same head.

13.7.2.2 Discharge over a 90° vee-notch shall be computed from one of the following equations:

a) If the vee-notch is cut in a polished brass plate:

Discharge in litres per minute $= \dfrac{H^{2.48}}{343{\cdot}3}$

Discharge in litres per second $= \dfrac{H^{2.48}}{20\,600}$

Discharge in cubic metres per hour $= \dfrac{H^{2.48}}{5\,720}$

where $H \approx$ *head over the notch in millimetres.*

b) If the vee-notch is out in a sheet of commercial steel plate:

Discharge in litres per minute $= \dfrac{H^{2.47}}{319}$

Discharge in litres per second $= \dfrac{H^{2.47}}{19\,150}$

Discharge in cubic metres per second $= \dfrac{H^{2.47}}{5\,320}$

where $H \approx$ head over the notch in millimetres.

For convenience, discharges computed from the above equations are given in Appendix B.

13.7.2.3 For accurate results, the following precautions shall be taken:

a) The thickness of the lip of the notch shall be 1·5 mm with a bevel of 45° leading downstream, and with the upstream edge perfectly sharp. The face of the notch shall be smooth and set vertically at right angles to the channel of approach and the sides of the notch shall be equally inclined to the vertical. A carefully finished notch made from polished brass plate or from a commercial steel plate is recommended, but the former is to be preferred. Rusting and pitting of the notch face may increase the discharge by as much as two percent above that computed from the above formulae.

b) The head shall be measured in the corners of the flume formed by the notch bulk head if the flume is sufficiently wide, or at the sides of the flume at a distance upstream from the notch, approximately four times the maximum head to be measured. The gauge shall preferably be placed in a separate gauge chamber connected to the flume by a pipe normal to the flume.

c) The depth from the apex of the notch to the bottom of the channel shall be not less than 150 mm on the downstream side, while on the upstream side, it shall be not less than 300 mm for heads up to 230 mm or less than 450 mm for higher heads.

d) The width of the channel of approach shall be not less than 1·2 m for heads up to 230 mm and less than 1·8 m for heads up to 450 mm.

e) There shall be no projecting surfaces whatever, either on the notch face or on the channel side, since these interfere with the smooth flow of the water to the notch

f) Swirling of water in the approach channel shall be prevented by suitably placing baffles upstream of the point at which the head is measured.

g) The water level downstream may be allowed to rise within 25 mm of the apex of the notch without affecting the result, but shall not be allowed to rise above this level when measurements are being taken

13.7.2.4 *Limits of accuracy* — If every care is taken with the setting and reading of the gauges, with the construction of the notch and the channel of approach, this method will give the discharge correct to within ±1·5 percent for heads between 75 and 375 mm.

13.7.3 *Rectangular weirs*

13.7.3.1 A rectangular weir provides a convenient and reliable method for the measurement of discharge exceeding 120 litres per minute.

13.7.3.2 The rectangular weirs shall be either.

a) 'suppressed' rectangular weirs with no side contractions of the stream lines, and with bottom contraction more or less complete, or

b) 'fully contracted' rectangular weirs with complete bottom and side contractions.

13.7.3.3 For accurate results, the following precautions shall be taken

a) The upstream face shall be flat and vertical;

b) The upstream crest edge shall be sharp and smooth, and the width of the crest shall be 1·5 mm with a bevel at 45° leading downstream from this;

c) The crest shall be level from end to end;

d) The overflowing sheet of water shall touch only the upstream crest face and the weir shall be so constructed as to ensure this,

e) The nappe shall be properly aerated (*see* Note 4 under **13.7.4.2**),

f) Swirling of the water in the approach channel shall be prevented, and the water shall approach the weir with a steady flow over the whole cross-sectional area of the approach channel This condition may best be obtained by suitably placed baffles, but the distance from the weir to the nearest baffle shall be at least ten times the maximum head to be measured In the case of suppressed weirs, the baffles shall take the form of screens or perforated plates, but for fully contracted weirs the baffles may be solid plates, provided the water passes under the baffles nearest the weir and at a velocity not exceeding 0 15 metre per second,

g) The head shall be measured at a point upstream and at a distance from the weir approximately six times the maximum head to be measured, and at the side of the approach channel,

h) The gauge should be placed in a separate gauge chamber to avoid turbulence effects, and

j) If the weir is in the open and its length exceeds 1 5 m, two gauges shall be used, one on each side, and the mean head adopted

13.7.4 *Suppressed rectangular weirs*

13.7.4.1 The width of the approach channel of a suppressed rectangular weir shall be equal to the length of the weir crest, and the downstream channel shall be of the same width for a distance of half a metre from the weir to prevent the nappe from spreading laterally.

13.7.4.2 For smooth sills of careful finish and with very sharp upstream edges, the discharge shall be computed from either of the following equations

a) *Discharge in litres per minute

$$= \frac{L}{955}\left(3\ 23 + 0{\cdot}434\,\frac{H}{P}\right) \quad (H \quad 1\ 04)^{1\ 5}$$

Discharge in litres per second

*These equations are applicable for weirs cut in polished brass plate with carefully prepared sharp upstream edges and smooth face with adequate provision for ventilating the nappe, the discharge computed by equation mentioned in **13.7.4.2** (*a*) would give accurate results.

$$= \frac{L}{57\,300}\left(3{\cdot}23 + 0{\cdot}434\,\frac{H}{P}\right) \times (H + 1{\cdot}04)^{1{\cdot}5}$$

Discharge in cubic metres per hour

$$= \frac{L}{15\,900}\left(3{\cdot}23 + 0{\cdot}434\,\frac{H}{P}\right) \times (H + 1{\cdot}04)^{1{\cdot}5}$$

where

L = length of weir crest in mm,
H = observed head on the weir in mm, and
P = height of the crest above the approach channel in mm.

b) *Discharge in litres per minute

$$= \frac{LH^{1{\cdot}47}\left(1 + 0{\cdot}56\,\frac{H^2}{d^2}\right)}{241}$$

Discharge in litres per second

$$= \frac{LH^{1{\cdot}47}\left(1 + 0{\cdot}56\,\frac{H^2}{d^2}\right)}{14\,460}$$

Discharge in cubic metres per hour

$$= \frac{LH^{1{\cdot}47}\left(1 + 0{\cdot}56\,\frac{H^2}{d^2}\right)}{4\,010}$$

where

L = length of weir crest in mm,
H = observed head on the weir in mm, and
d = area of cross-section of approach channel in mm² divided by length of weir crest in mm.

Note 1 — No addition to the observed head shall be made for velocity of approach in using the above equations, as allowance for such velocity is already included. Full bottom contraction is not essential.

Note 2 — Sills that are not smoothly finished should not be used for testing purposes but where their use is unavoidable, limits of accuracy shall be widened.

Note 3 — The weir crest shall be at a height above the approach channel of not less than 1·5 times the maximum head to be measured and not more than 1·2 m. It shall be so placed that it is possible to aerate the nappe fully and to prevent downstream water level rising higher than 80 mm below the crest.

Note 4 — Particular attention shall be given to effective aeration of the nappe, failing which the computed discharge will be much too low, due to the formation of partial vacuum under the nappe. To avoid inaccuracies due to this cause, openings shall be provided in the side walls close below the crest. The total area of these openings shall be not less than 70 *LH* cm², where

L = length of weir crest in metres, and
H = observed head on weir in metres.

13.7.4.3 *Limits of accuracy* — If every care is taken with the setting and the reading of the gauges, and with the construction of the weir and the channel of approach, the above equations will give the discharge correct to within ±1·5 percent for heads between 50 and 750 mm.

13.7.5 *Fully Contracted Rectangular Weirs*

13.7.5.1 Neither of the sides of the channel of approach of a fully contracted rectangular weir shall be nearer any point of the weir crest than four times the head, and the distance from the bottom of the channel to the weir crest shall be not less than three times the head. The minimum distance in every direction shall be 300 mm.

13.7.5.2 Neither the bed nor the sides of the channel downstream from the weir shall be nearer the weir than 150 mm. The downstream water level shall not be allowed to rise higher than 80 mm below the weir crest.

13.7.5.3 These conditions are necessary to ensure that:

a) every drop of water passing over the weir assumes that direction which it would take, if poured out of a pool of infinite dimensions;
b) the water may be spread freely sideways after leaving the weir; and
c) there may be a space immediately under the nappe or falling water in direct communication with the atmosphere.

*These equations are applicable for weirs cut in commercial steel plates, where the above conditions, namely, the sharp upstream edges and smooth face, are not obtained, the discharge computed by the equation mentioned in 13.7.4.2 (b) would give correct results.

13.7.5.4 For rectangular weirs of any length from 300 mm upwards having complete contractions and furnished with carefully finished sills having a very sharp upstream edge, the discharge shall be computed from the following equations:

a) Discharge in litres per minute $= \dfrac{(L - 0{\cdot}1\ H)H^{1{\cdot}5}}{290}$

b) Discharge in litres per second $= \dfrac{(L - 0{\cdot}1\ H)H^{1{\cdot}5}}{17\ 400}$

c) Discharge in cubic metres per hour $= \dfrac{(L - 0{\cdot}1\ H)H^{1{\cdot}5}}{4\ 840}$

where

L = length of weir in mm, and

H = observed head on the weir in mm.

These equations may be used for heads from 80 to 600 mm provided that $\dfrac{L}{H}$ is greater than 2.

NOTE — Sills that are not smoothly finished should not be used for testing purposes and where their use is unavoidable, the limits of accuracy shall be widened.

13.7.5.5 *Limits of accuracy* — If every care is taken in setting and reading of the gauges, and in the construction of the weir and the channel of approach, and provided that the head on the weir is not less than 80 mm, the above equations will give the discharge correct to within ± 2 percent.

13.7.6 *Other Methods* — Other methods of measurement with water-meter, pitch tube, flow, nozzle and venturi meter may also be used, provided the apparatus has been carefully calibrated against a vee-notch or rectangular weir.

13.8 *Measurement of Head*

13.8.1 In the laboratory test, the head is created artificially by throttling the sluice valve placed beyond the delivery flange of pump at least six times the diameter downstream of the pressure gauge connection.

13.8.2 The standard method of measuring head shall be to employ a water column gauge glass giving a direct or surface elevation. Where this cannot be used, indirect methods may be employed, such as the use of mercury or other fluid gauge or a Bourdon tube gauge.

13.8.3 It is recommended that water or mercury manometers be used in preference to Bourdon type gauges when the head to be measured is 7·5 m or less.

13.8.4 *Precautions and Connections for the Gauges*

13.8.4.1 For suction gauge reading a manometer or a pressure vacuum gauge shall be attached near the suction flange to a piece of straight pipe interposed between the pump suction flange and valve or bend at the centre of the pipe in the horizontal plane. The length of this straight pipe shall be not less than four times the diameter of the pipe subject to a maximum of 1·5 m and a minimum of 300 mm (the reason is that, since the flow is shifted toward the outer periphery of a bend, the resulting higher velocity there would indicate lower pressure)

13.8.4.2 For delivery gauge, Bourdon type pressure gauge/manometer shall be attached to the centre of a straight parallel pipe connected directly to the delivery flange. The nominal diameter of the straight pipe shall be equal to the delivery size of the pumps. The length of the straight parallel pipe shall be not less than four times the diameter of the pipe subject to a maximum of 1·5 m and a minimum of 300 mm.

13.8.4.3 When water columns are used, care shall be taken to avoid errors due to the difference between the temperature of the water in the gauge connection and that of a water in the pump by frequently draining the connection or determining the necessary correction.

13.8.4.4 When Bourdon type gauges are used, they shall be of suitable range for the heads to be measured (the gauge range should be about twice the maximum head to be measured). It is recommended that the drain cocks be placed immediately below the gauges and that frequent tests be made to determine whether pipe connections of the gauge are filled with water. With this form of gauge, care shall be taken to eliminate any leaks in the connecting pipes, and to avoid the trapping of air in the connecting pipe or hose.

13.8.4.5 The gauges shall be calibrated prior to/or after the test and when calibrated and used, shall be in an upright position. On no account shall any Bourdon type gauge be fixed so that any strain is placed on its case, as its readings may thereby be seriously affected.

13.8.4.6 The end of the connecting tube or pipe shall be flush with the inside of the conduit in which the pressure is to be measured and shall have its axis at right angles to the direction of flow.

13.8.5 *Limits of accuracy* — With the above precautions, and provided the head to be measured is reasonably steady, an accuracy with ± 1 percent may be expected.

13.9 *Measurement of Power Input*

13.9.1 The measurements of power input fall into two general classes:

a) Some measurements are those which themselves determine the actual power or torque delivered to the pump and are, therefore, made entirely during the test, using some form of transmission dynamometer.

b) Other measurements are those which involve measurement, during the pump test, of power input to the driving element, and the previous or subsequent determination of the relation of the power input to the power output of this driving element under identical conditions of the pump test, thus deriving the efficiency of the driving element.

13.9.2 *Corrections and allowances* — Power delivered to the pump shaft when directly connected shall be the power output of the driving element When not directly connected, corrections shall be made for the losses between the driving element and the pump. In the case of flat belt and V-belt drives, the allowances for belt losses may be taken as 6 and 3 percent respectively.

13.10 *Large Pump Test*

13.10.1 On all pumps or bowl assemblies where the power is not in excess of 75 kW, the actual pump shall be tested in the manufacturer's laboratory.

13.10.2 If the power exceeds 75 kW, it shall be permissible for the manufacturer to test only the number of stages of the unit which come within the power requirements. If a test is made on a limited number of stages, no increase in efficiency shall be allowed for an increased number of stages when predicting the final performance of the complete bowl assembly. The head and power shall be increased in direct proportion to the number of stages in the final assembly, compared with the number of stages used in the laboratory test.

13.10.3 When the size of the bowl exceeds 400 mm outside diameter, a laboratory test on model pump, homologous with the actual unit, may be used as a basis for the determination of the performance of the actual unit.

13.10.3.1 In general, when contract guarantees are to be based on model tests, the contract should specify model performance rather than inferred actual unit performance. In the absence of this provision, allowance for the scale effect, if any, shall be agreed upon in writing by the representatives of both parties prior to finalization of order.

13.10.4 *Test of full sized pump at reduced speeds* — On all pumps or bowl assemblies (which have an outside diameter exceeding 400 mm) which require more than 75 kW, it shall be permissible to test the actual pump or bowl assembly at a speed lower than the specified speed. The reduced speed tests are in general closely representative of tests at full speed. In tests at reduced speed, the relative power loss in bearing and stuffing box friction may be increased, an effect which may be appreciable in small pumps. The hydraulic friction losses may be relatively increased when the Reynolds number for the water passages is reduced, an effect which may be appreciable in small pumps of low specific speed. Therefore, these factors shall be considered in determining an acceptable reduced test speed.

In order to maintain the hydraulic similarity, the similarity relations given in **13.3.2** shall be used for head and discharge to calculate these quantities at the specified speed from the actual measured head and discharge. The efficiency at the specified speed shall be calculated by using the relationship given below:

$$\frac{1-\eta_1}{1-\eta_s} \quad \left(\frac{N_s}{N_1}\right)^n$$

where

η_1 = efficiency at actual test speed,

η_s = efficiency at specified speed,

N_s = specified speed,

N_1 = actual test speed, and

n = exponent established by test data, the value of the exponent is 0·17.

13.10.5 All large bowl assembly full speed tests or model tests shall be conducted in a manner that the submergence would be that specified by the manufacturer.

13.11 *Hydrostatic Tests* — A standard hydrostatic test on the pump or bowl assembly shall be made at one-and-a-half times the maximum discharge pressure.

14. Determination of Pump Performance when Handling Viscous Liquids

14.0 Figure 25 provides means of determining the performance of a rotodynamic pump handling a viscous liquid when its performance on water is known. It may also be used as an aid in selecting a pump for a given application.

14.1 *Limitations on the use of performance correction chart for viscous liquid (see Fig. 25)* :

a) use only for pumps of conventional hydraulic design, in the normal operating range, with open or closed impellers. Do not use for mixed-flow or axial-flow pumps or for pumps of special hydraulic design for either viscous or non-uniform liquids;
b) use only where adequate *NPSH* is available in order to avoid the effect of cavitation; and
c) use only on Newtonian (uniform) liquids. Gels, slurries, paper stock and other non-uniform liquids may produce widely varying results, depending on the particular characteristics of the liquids.

14.2 Symbols and definitions are used in the determination of pump preformance when handling viscous liquids.

These symbols and definitions are:

Q_{vis} = viscous capacity, m³/h (the capacity when pumping a viscous liquid);
H_{vis} = viscous head, metres (the total head when pumping a viscous liquid);
E_{vis} = viscous efficiency, percent (the efficiency when pumping a viscous liquid);
P_{vis} = viscous power (the power required by the pump for the viscous condition);
Q_w = water capacity, m³/h (the capacity when pumping water);
H_w = water head, metres (the total head when pumping water);
E_w = water efficiency, percent (the efficiency when pumping water);
sp gr = specific gravity;
K_Q = capacity correction factor;
K_H = head correction factor;
K_E = efficiency correction factor; and
Q_N = water capacity at which maximum efficiency is obtained.

14.3 The following are the equations used for determining the viscous performance when water performance of the pump is known:

a) $Q_{vis} = K_Q \times Q_w$
b) $H_{vis} = K_H \times H_w$
c) $E_{vis} = K_E \times E_w$
d) $P_{vis} = \dfrac{Q_{vis} \times H_{vis} \times \text{sp gr}}{367 \times E_{vis}}$

K_Q, K_H, and K_E are determined from Fig. 25 based on the water performance.

The following equations are used for approximating the water performance when the desired viscous capacity and head are given and the values of C_Q and C_H shall be estimated from Fig. 25 using Q_{vis} and H_{vis} as:

$$Q_w \text{ (approx)} = \frac{Q_{vis}}{K_Q}$$

$$H_w \text{ (approx)} = \frac{H_{vis}}{K_H}$$

14.4 Instructions for preliminary selection of a pump for a given head capacity and viscosity conditions are as follows:

a) Given the desired capacity and head of the viscous liquid to be pumped, the viscosity and specific gravity at the pumping temperature chart (Fig. 25) may be used to find approximate equivalent capacity and head when pumping water.

b) Enter the chart (Fig. 25) at the bottom with the desired viscous capacity (Q_{vis}) and proceed upward to the desired viscous head (H_{vis}) in metres of liquid. For multistage pumps, use head per stage. Proceed horizontally (either left or right) to the fluid viscosity, and then go upward to the correction curves. Divide the viscous capacity (Q_{vis}) by capacity correction factor (K_Q) to get the approximate equivalent water capacity (Q_w approx). Divide the viscous head (H_{vis}) by the head correction factor (K_H) from the curve marked '$1 \cdot 0 \times Q_N$' to get the approximate

equivalent water head (H_W approx). Using this new equivalent water head capacity point select a pump in the usual manner. The viscous efficiency and the viscous brake horsepower may then be calculated.

c) This procedure is approximate as the scales for capacity and head on the lower half of Fig. 25 are based on the water performance. However, the procedure has sufficient accuracy for most pump selection purposes.

14.5 Instructions for determining pump performance on a viscous liquid when performance on water is known are as follows:

a) Given the complete performance characteristics of a pump handling water, determine the performance when pumping a liquid of a specified viscosity.

b) From the efficiency curve, locate the water capacity ($1{\cdot}0 \times Q_N$) at which maximum efficiency is obtained. From this capacity, determine the capacities ($0{\cdot}6 \times Q_N$), ($0{\cdot}8 \times Q_N$) and ($1{\cdot}2 \times Q_N$). Enter the chart at the bottom with the capacity at best efficiency ($1{\cdot}0 \times Q_N$), go upward to the head developed in one stage (H_W) at this capacity then horizontally (either left or right) to the desired viscosity, and then proceed upward to the various correction curves. Read the values of K_E and K_Q, and of K_H for all four capacities. Multiply each head by its corresponding head correction factor to obtain the corrected heads. Multiply each efficiency value by K_E to obtain the corrected efficiency values which apply at the corresponding corrected capacities.

c) Plot corrected head and corrected efficiency against corrected capacity, drawing smooth curves through these points. The head at shut-off can be taken as approximately the same as that for water.

d) Calculate the viscous brake horsepower (bhp_{vis}) from the formula given above.

e) Plot these points and draw a smooth curve through them which should be similar to an approximately parallel to the brake horsepower (*bhp*) curve for water.

Example:

Given the performance of a pump (Fig. 30) obtained by test on water, plot the performance of this pump when handling oil with a specific gravity of 0·90 and a viscosity of 210 cSt at pumping temperature.

On the performance curve (Fig. 27) locate the best efficiency point which determines Q_N. In this case, it is 47 l/s. Tabulate capacity, head and efficiency for ($0{\cdot}6 \times 750$), ($0{\cdot}8 \times 750$) and ($1{\cdot}2 \times 750$).

Using 47 l/s, 30 metres head and 210 cSt, enter the chart and determine the correction factors. These are tabulated in Sample Performance Chart. Multiply each value of head, capacity and efficiency by its correction factor to get the corrected values. Using the corrected values and the specific gravity, calculate brake horsepower

15. Guarantees

15.1 *Guarantee of Workmanship and Material* — The pumps shall be guaranteed by the manufacturer against defects in material and workmanship under normal use and service, for a period of at least one year from the date of despatch.

15.2 *Guarantee of Performance* — The supplier shall indicate the working range of the pump and the efficiency of the pump shall be guaranteed at a specified point of rating only and shall not be guaranteed to cover the performance of the pump under conditions varying therefrom nor for a sustained performance for any period of time. If the purchaser so desires, the manufacturer shall guarantee the non-overload of the prime mover for variations in the head in the working range. In the case of pumps where acceptance tests cannot be conducted on the liquid for which the pump is designed, the manufacturer shall indicate the liquid performance of the pump based on the results of the tests conducted by him on the pump with water as indicated under **13** and interpolated as explained under **14**. However, in these cases, the manufacturer shall guarantee for the performance of the pump with water for the specified range.

16. Tolerances

16.1 In all commercial acceptance tests of pumps, a certain tolerance shall be allowed to the manufacturer on his guarantee to cover inaccuracies of the equations for discharge, errors of observation and unavoidable minor inaccuracies of the instruments employed.

16.2 A tolerance of $\pm 2{\cdot}5$ percent shall be permissible on the discharge. However, for small discharges up to 900 litres per minute, a tolerance of $+2{\cdot}5$ percent or $+24$ litres per minute, whichever is higher, is allowed, while the negative tolerance of 2·5 percent is maintained.

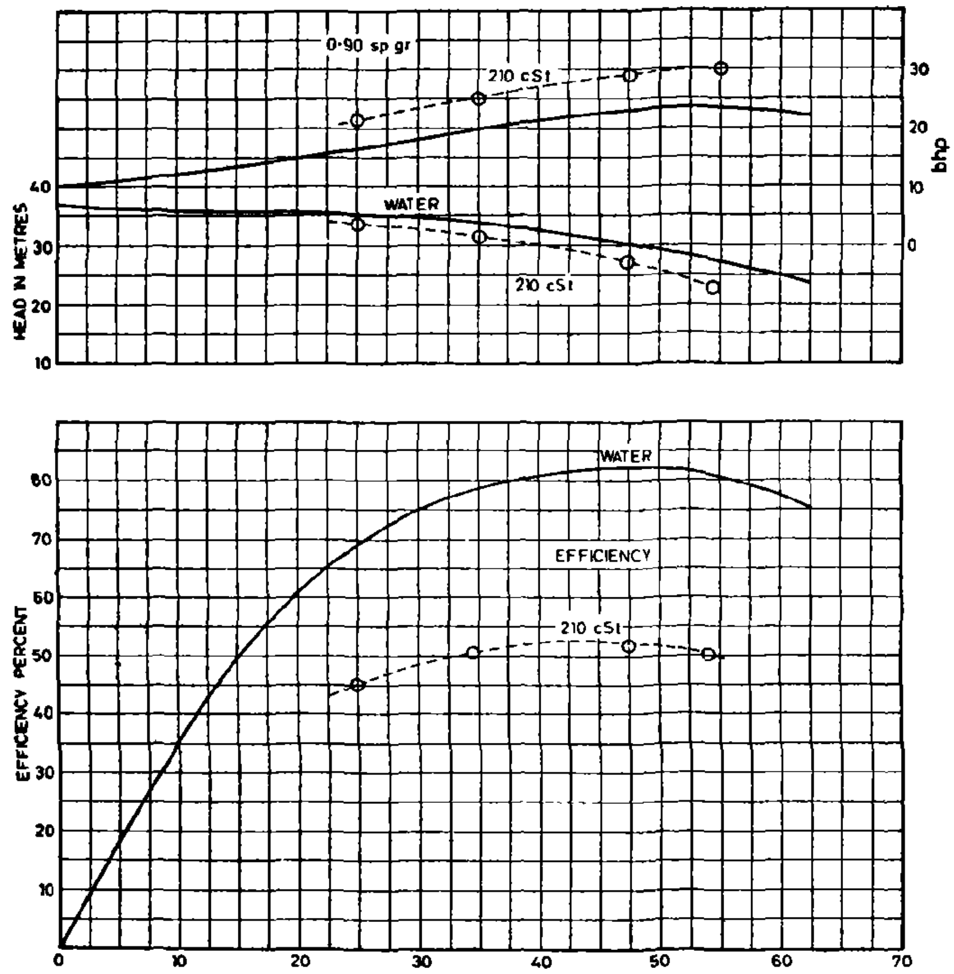


FIG. 30 SIMPLE PERFORMANCE CHART

16.3 The pump efficiency shall be not less than the specified value by more than 2·5 percent. This tolerance may be raised to 5 percent in case the prime mover does not get overloaded.

17. General Requirements

17.1 *Performance* — The specified range shall lie on the stable portion of the head characteristic curve. This is applicable in case of parallel operations of pumps only.

17.2 *Suction and Delivery Ends* — The size of the suction end of a double suction pump should preferably be one size larger than that of the delivery. This is to offset the increased loss in the suction. Typical practices of pipes used are:

85/65, 100/75, 125/100, 150/125, 200/150 and 250/200 mm, etc.

17.2.1 For a high pressure pump, a reflux valve shall be connected on the delivery side.

17.3 *Fluid Passages* — All the liquid passages in the casing and the impeller which are inaccessible to machining shall be finished to smooth surfaces as far as possible.

17.4 *Draining Plugs* — Tapped drain holes with plugs shall be provided for draining the fluid that may drip from the sealing arrangement. The sealing arrangement shall be sufficiently deep to provide for sufficient quantity of packing to prevent leakage of air.

17.5 *Lantern Ring* — In case, where a lantern ring is used in a stuffing box, it shall be sandwiched between rows of packings and shall be easily removable.

17.6 *Casing* — Casing shall be of robust construction and tested to withstand a hydrostatic test pressure of 1·5 times the maximum discharge pressure.

17.7 *Impeller* — The impeller shall be properly balanced alongwith any other unmachined rotating parts on proper balancing equipment so as not to cause any vibration.

17.8 *Shaft* — The shaft shall be finished to close tolerances at the impeller coupling, pulley and bearing diameters. The impeller, pulley and shaft sleeves shall be firmly secured to the shaft by keys or nuts or both.

17.9 *Shaft Couplings* — Shaft couplings, where provided, shall be properly aligned and firmly secured to the shaft by keys or nuts or both

17.10 *Bearings* — The bearings may be ball, roller or sleeve bearings. In the latter case, some sort of thrust bearings are necessary. If sleeve bearings are used, they are to be machined for close running fit. The bearings shall be so designed as to take up the necessary radial load as well as the net hydraulic axial thrust. Bearings shall be lubricated properly

17.10.1 The bearings should be designed for a minimum life of 20 000 hours or 40 000 hours as required The bearing housings shall be designed in such a manner that no liquid being pumped should enter the housing

17.10.2 Where there is a possibility of fluid entering the bearings, the pump shall be provided with suitable preventive arrangements, for example, deflectors.

17.11 *Stuffing Boxes* — The stuffing boxes shall be extra deep and provided with a cooling water jacket if so required. In addition, provision for tapping off the leakage liquid shall also be made. The packing materials employed shall be suitable for withstanding the special conditions such as temperature, corrosion due to the fluid being handled, etc. Wherever possible, suitable mechanical seals may be used.

17.12 *Base Plates* — The base plate which accommodates the pump or the pump and the prime mover, when provided, shall be rigid and stable so that alignment is not affected under normal working conditions.

17.13 *Prime Mover* — The prime mover shall be of such a capacity as to provide, under working site conditions, a power which is more than the maximum power required by the pump at any point in the specified range. Should a specific margin be required by the customer in the power of the prime mover, he should so advise the manufacturer for obtaining the proper recommendations.

17.14 *Name Plate* — Every pump shall have a name plate indicating.

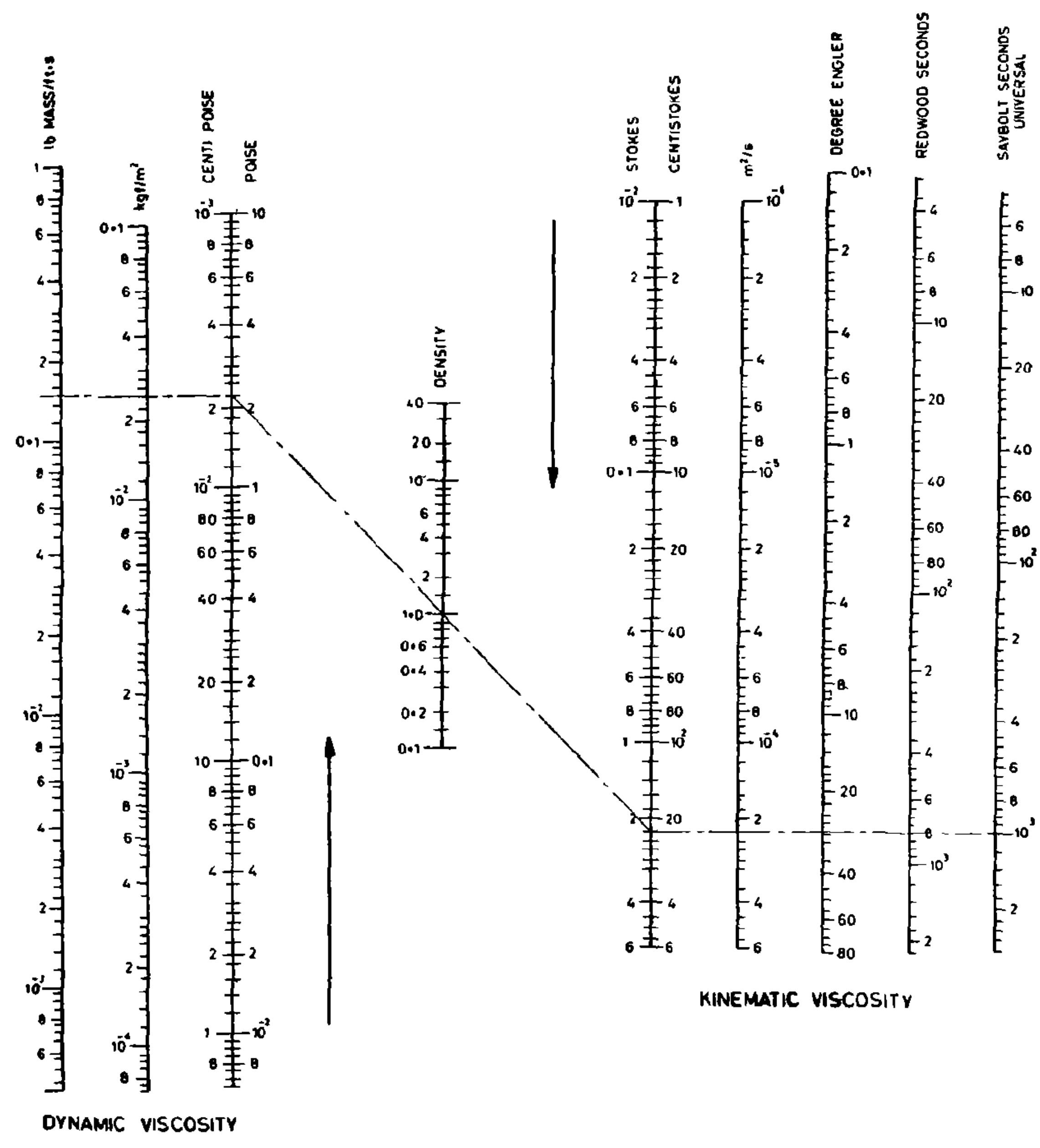
a) name and address of the pump manufacturer;
b) type, size, and serial number of the pump; and
c) speed, total head, capacity and corresponding pump input for the duty point.

17.14.1 For corrosive liquids the material of the name plate shall be suitable to withstand the corrosive atmosphere.

APPENDIX A

(Note under Clause 2.5)

ALIGNMENT CHART FOR VISCOSITY CONVERSION



APPENDIX B

(*Clause* 13.7.2.2)

DISCHARGE TABLES

B-1. Discharge of Water Over a 90° Vee-Notch Cut in Polished Brass Plate

B-1.1 *Discharge Rate Formulae*

a) Discharge in litres per minute $= \dfrac{H^{2.48}}{343\ 3}$

b) Discharge in litres per second $= \dfrac{H^{2.48}}{20\ 600}$

c) Discharge in cubic metres per hour $= \dfrac{H^{2.48}}{5\ 720}$

B-1.2 For convenience of reference, discharges computed from above equations are given in Table 8.

TABLE 8 DISCHARGES OF WATER OVER A 90° VEE-NOTCH CUT IN POLISHED BRASS PLATE

H mm	Litres/Minute	Litres/Second	Cubic Metres/hour	*H* mm	Litres/Minute	Litres/Second	Cubic Metres/hour
(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
75	130 15	2 169	7 81	230	2 095 92	34 932	125 75
80	152 74	2 546	9 16	235	2 210 70	36 845	132 64
85	177 52	2 959	10 65	240	2 329 02	38 817	139 75
90	204 55	3 409	12 27	245	2 451 48	40 858	147 09
95	233 90	3 898	14 03	250	2 577 36	42 956	154 64
100	265 63	4 427	15 94	255	2 707 08	45 118	162 42
105	299 80	4 997	17 99	260	2 840 58	47 343	170 43
110	336 46	5 608	20 19	265	2 978 10	49 635	178 69
115	375 68	6 261	22 54	270	3 119 22	51 987	187 15
120	417 50	6 958	25 05	275	3 264 48	54 408	195 87
125	461 98	7 698	27 72	280	3 413 82	56 897	204 83
130	509 16	8 486	30 55	285	3 566 82	59·447	214·01
135	559 12	9 319	33 55	290	3 724 20	62 070	223 45
140	611 88	10 198	36 71	295	3 885 36	64 756	233 12
145	667 56	11 126	40 05	300	4 050 78	67 513	243 05
150	726 06	12 101	43 56	305	4 220 28	70 338	253 22
155	787 62	13 127	47 26	310	4 393 92	73 232	263 63
160	852 12	14 202	51 13	315	4 571 88	76 198	274 31
165	919 68	15 328	55 18	320	4 753 92	79 232	285 23
170	990 35	16 506	59 42	325	4 940 16	82 336	296 41
175	1 064 22	17 737	63 85	330	5 130 72	85 512	307 84
180	1 141 20	19 020	68 47	335	5 325 72	88 762	319 54
185	1 221 42	20 357	73 28	340	5 525 22	92 087	331 52
190	1 304 88	21 748	78 29	345	5 728 92	95 482	343 73
195	1 391 70	23 195	83 50	350	5 937 00	98 950	356·22
200	1 481 94	24 699	88 92	355	6 150 00	102 50	368·98
205	1 575 54	26 259	94 53	360	6 366 60	106 11	381 99
210	1 672 62	27 877	100 36	365	6 588 00	109 80	395 28
215	1 773 06	29 551	106 39	370	6 814 20	113 57	408 85
220	1 877 04	31·284	112 62	375	7 044 60	117 41	422 69
225	1 984 68	33 078	119 08	380	7 279 80	121·33	436 80

B-2. Discharge of Water Over a 90° Vee-Notch Cut in Commercial Steel Plate

B-2.1 *Discharge Rate Formulae*

a) Discharge in litres per minute $= \dfrac{H^{2.47}}{319}$

b) Discharge in litres per second $= \dfrac{H^{2.47}}{19\ 150}$

c) Discharge in cubic metres per hour $= \dfrac{H^{2.47}}{5\ 320}$

B-2.2 For convenience of reference, discharges computed from the above equations are given in Table 9.

TABLE 9 DISCHARGES OF WATER OVER A 90°-VEE-NOTCH CUT IN COMMERCIAL STEEL PLATE

H mm	Litres/Minute	Litres/Second	Cubic Metres/hour	*H* mm	Litres/Minute	Litres/Second	Cubic Metres/hour
(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
75	134·12	2 236	8 05	230	2 135 82	35 597	128 15
80	157·30	2 621	9 44	235	2 252 34	37·539	135·14
85	182·71	3 045	10 96	240	2 372 52	39·542	142 35
90	210 41	3 507	12 62	245	2 496 54	41 609	149 79
95	240 47	4 008	14 43	250	2 624 22	43 737	157 45
100	272 95	4 549	16 38	255	2 755 74	45 929	165 34
105	307 91	5 132	18 48	260	2 891·16	48·186	173·46
110	345 40	5 757	20 72	265	3 030 54	50 509	181 83
115	385 50	6 425	23 13	270	3 173 58	52 893	190 41
120	428·21	7 137	25 68	275	3 320 76	55 346	199 25
125	473·65	7 894	28 42	280	3 472 02	57 867	208 32
130	521 82	8 697	31 31	285	3 626 94	60·449	217 61
135	572 81	9 547	34 37	290	3 786 36	63 106	227 18
140	626 64	10 444	37·60	295	3 949 62	65·827	236 97
145	683 40	11 390	41 00	300	4 117 02	68 617	247 02
150	743·10	12·385	44 58	305	4 288 62	71 477	257 31
155	805 74	13 429	48 35	310	4 464 30	74 405	267 86
160	871 50	14 525	52 29	315	4 644 30	77 405	278 66
165	940 32	15 672	56 42	320	4 828 50	80 475	289 70
170	1 012 56	16 871	60 74	325	5 016 84	83 614	301 01
175	1 087 44	18 124	65 25	330	5 209 68	86 828	312 58
180	1 165 80	19 430	69 94	335	5 406 84	90 114	324 41
185	1 247 40	20 790	74 84	340	5 608 56	93 476	336 51
190	1 332 30	22·205	79 94	345	5 814 48	96 908	348 87
195	1 420 56	23 676	85 23	350	6 024 60	100 41	361 48
200	1 512·30	25·205	90 74	355	6 239 40	103 99	374 37
205	1 607 40	26 790	96 44	360	6 459 00	107·65	387 53
210	1 705 98	28 433	102 30	365	6 682 80	111 38	400 96
215	1 808·10	30 135	108 48	370	6 910 80	115·18	414·66
220	1 913 70	31 895	114 82	375	7 114·20	119 07	428 64
225	2 022 90	33 715	121 37	380	7 381 80	123 03	442 89

EXPLANATORY NOTE

This standard was originally issued in 1968. The first revision incorporates certain changes in respect of the terminology and pump tests.

Printed at Simco Printing Press, Delhi, India